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VOL. 24 AUGUST, 1931 No. 4

Proceedings of the Sixth Annual Meeting of the Cotton States Branch, American Association of Economic Entomologists

The sixth annual meeting of the Cotton States Branch was held at Atlanta, Georgia, on February 5 and 6, 1931. The meeting was well attended, there being 72 names listed. The attendance on the first day was 61, and that on the second day was 65. The program required two long sessions at which special attention was given to cotton insects, including the pink bollworm, and to the results of investigations of insects attacking other crops grown in the southern region.

Twenty-three papers were presented. In order to complete the program during the two scheduled sessions and in fairness to each participant, the time limit rule of ten minutes for each paper was enforced. The papers presented were classified as follows:

Insects Injurious to Cotton	7
Insects Injurious to Peaches	5
Insects Injurious to Field Crops	3
General Subjects	3
Pests Injurious to Sugarcane	2
Insects Injurious to Pecan and Other Trees	2
Household Insects	1

The president of the Entomological Society of America, J. W. Folsom, was in attendance, and he was presented to the meeting in his official capacity. Special recognition was given to the attendance upon our meeting of F. C. Bishopp and S. B. Fracker of Washington. The members of the Cotton States Branch were guests at banquets on the nights of February 4 and 5.

Demonstrations and exhibits were special features of the sixth annual meeting. The State Plant Board of Mississippi presented a large exhibit which was marked by its completeness and system of prepara-

tion. There were two exhibits from Texas which were very informative of certain types of entomological work performed in that state. A number of demonstrations of a gin trash machine were given by representatives of the U. S. Plant Quarantine and Control Administration.

PART I. BUSINESS PROCEEDINGS

The meeting was called to order by Chairman J. M. Robinson at 2:00 P. M. on February 5 in the Biltmore Hotel at Atlanta, Georgia. The following members were present:

Alden, C. H., Cornelia, Ga.
Arnold, G. F., A. & M. College, Miss.

Bentley, G. M., Knoxville, Tenn.
Bishopp, F. C., Washington, D. C.
Bissell, Theo. L., Experiment, Ga.
Butler, H. G., Harriman, Tenn.

Carpenter, H. H., Houston, Miss.
Chance, O. M., Jackson, Miss.
Clarke, W. H., Thomaston, Ga.
Colmer, R. P., Moss Point, Miss.

Deen, R. B., Tupelo, Miss.
Deuberry, E. P., Knoxville, Tenn.
Dietrich, Henry, Lucedale, Miss.
Douglass, N. L., Grenada, Miss.
Dunavan, David, Clemson College, S. C.
Dunnam, E. W., Bryan, Texas.

Eddy, C. O., Clemson College, S. C.

Farlinger, D. F., Cornelia, Ga.
Fattig, P. W., Emory University, Ga.
Folsom, J. W., Tallulah, La.

Gay, G., Charleston, S. C.
Gill, J. B., Albany, Ga.
Gray, W. L., Natchez, Miss.

Hamilton, D. W., Cornelia, Ga.
Hamner, A. L., A. & M. College, Miss.
Harned, R. W., A. & M. College, Miss.
Harris, J. A., Raleigh, N. C.

Ingram, J. W., Houma, La.

Kile, H. J., Knoxville, Tenn.
Kislanko, J. P., Wiggins, Miss.

Langston, J. M., A. & M. College, Miss.
Leiby, R. W., Raleigh, N. C.
Lyle, Clay, A. & M. College, Miss.

Marcovitch, S., Knoxville, Tenn.
Milton, J., Corinth, Miss.
Moody, D. C., Cornelia, Ga.
Moser, J. C., Knoxville, Tenn.
Munger, F., Cornelia, Ga.

McEvilly, J. E., McComb, Miss.

Newell, Wilmon, Gainesville, Fla.

Peets, N. D., Brookhaven, Miss.

Robinson, J. M., Auburn, Ala.

Sherman, Franklin, Clemson College, S. C.
Smith, F. A., Senatobia, Miss.
Snapp, Oliver I., Fort Valley, Ga.
Spencer, Herbert, Albany, Ga.
Steiner, L. F., Cornelia, Ga.
Swingle, H. S., Auburn, Ala.

Thomas, F. L., College Station, Texas.
Thomson, J. R., Fort Valley, Ga.

Yeomans, M. S., Atlanta, Ga.

Report of the Treasurer

Balance on hand, Feb. 6, 1930		$ 45.17
Refund from parent association for expenses ending Feb. 5, 1930		28.28
Contributions from four entomologists		4.00
1929 annual dues from 7 members		7.00
1930 annual dues from 37 members		37.00
1931 annual dues from 4 members		4.00
Paid out:		
Stamped envelopes	$ 14.63	
Stamps	1.00	
Cards	.30	
Telegram	.72	
Printing announcements and programs	7.00	
	$ 23.65	$125.45
Balance on hand Feb. 6, 1931	$101.80	
	$125.45	

Report of the Secretary

The number of members in the Cotton States Branch on December 31, 1930, was 238. There was a net increase of 22 members during the year, after dropping those who had moved out of the Branch territory or who were dropped by the parent Association for non-payment of dues. This large increase in membership was due largely to the continued effort on the part of the Branch to secure new members. The net increase in 1929 was 11. During the last four years the membership has grown from 158 to 238 or a net increase of 80 members, after dropping those who had moved out of the Branch territory during that period or who had not kept up their dues in the parent Association. So the number of new members added to the Branch roll during the last four years was even more than the number represented by the increase in the Branch membership.

The number of members by states at the close of 1930 was as follows: Texas 48; Louisiana 36; Mississippi 36; Florida 28; Georgia 21; Tennessee 19; North Carolina 16; South Carolina 13; Alabama 9; Arkansas 8; Oklahoma 4. The following states showed net increases during the year: Georgia 7; Florida 6; South Carolina 4; Texas 3; Mississippi 2; Oklahoma 2; Tennessee 2; Arkansas 1. These states showed net decreases: Alabama 2; Louisiana 2; North Carolina 1.

There are now 442 entomological workers in the 11 Cotton States who are not members of this Branch. Many of these are eligible, and members are urged to assist in continuing our efforts to strengthen the Branch by increasing the membership.

Complying with the report of the committee on policy which was adopted at our last annual meeting, your Secretary on December 1 sent to each member of the Branch an invitation to participate in the annual meeting to be held in Atlanta, Georgia, on February 5 and 6, but reminded them of the action taken by the Branch in regard to papers, namely, (1) a time limit of ten minutes is established for each paper at the annual meetings, and (2) to be eligible for acceptance, the title of a paper must be sent to the Secretary before January 1, together with an estimate of the time required for the presentation of the paper. The program for the meeting this year is unusually long, and in order to finish it during the two scheduled sessions and in fairness to each participant, the time limit rule for each paper presented must be *strictly* enforced.

The program for the Atlanta meeting was mailed to each member of the Branch two weeks in advance of the meeting.

At a business session of the Branch in 1928 the annual dues were fixed at $1.00. Only 48 of the 216 members in 1929 paid their annual dues, and only 38 of the 238 members have paid their 1930 dues. This matter was brought to the attention of the members in the announcement which was mailed on December 1. Four members have paid their 1931 dues. The dues for this year are now payable.

Chairman Robinson announced the committee appointments as follows: Nominations, F. L. Thomas, A. L. Hamner, and E. W. Dunnam. Resolutions, R. W. Harned, R. W. Leiby, and H. S. Swingle. The following standing committees were announced: Policy, R. W. Harned, Oliver Snapp, and J. W. Folsom. Publications, Oliver Snapp and Herbert Spencer.

Final Business

The final business was transacted late in the afternoon of February 6. Chairman Robinson called for the report of committees.

Report of the Committee on Policy: This committee recommended (1) That the permanent standing committee on policy be discharged and its duties and responsibilities placed in an Executive Committee of five consisting of the three officers elected each year and the two last past chairmen. (2) That the Secretary be elected for a three-year period. These recommendations were adopted by motion and vote.

The Publications Committee called attention to the fact that an abstract must accompany all papers presented for publication, and instructed those who read papers at the meeting to send them with abstracts to the Secretary at the earliest date if they have not already been turned in.

The following report of the joint committee on Policy and Publications was adopted by motion and vote:

"The Cotton States Branch officially approves the action which was taken by the Executive Committee of the parent Association, and approved by the American Association of Economic Entomologists at the Cleveland meeting, that each officially recognized Branch of the parent Association be allowed the publication of 50 pages in the Journal of Economic Entomology, of its annual proceedings without charge to the Branch; that the next 50 pages or portion thereof, if any, be published by the Journal at a price of $1.50 per page, to be defrayed by the Branch; that matter in excess of 100 pages be published at a price of $3.00 per page, to be paid by the Branch concerned."

The following report of the Resolutions Committee was accepted and adopted by motion and vote:

"*Resolved, That:* A vote of thanks be given to Dr. P.W. Fattig of Emory University for the use of his lantern and for his personal assistance throughout these meetings. We hope that as many as possible will cooperate with him in his studies of *Mutillids*.

"This Association extends to the Southern Beekeeping Conference at its February 18–19 meeting at Montgomery, an invitation to consider holding its 1932 meeting at the same time and place as that of the Southern Agricultural Workers.

"The Association commends the U. S. Department of Agriculture and the Florida State Plant Board for their success thus far in the eradication of the Mediterranean fruit fly and hopes that this project will be properly supported to a successful conclusion.

"The Association thanks the management of this hotel for their hospitality."

The Nominations Committee presented the following names for officers during the ensuing year: Chairman, R. W. Harned, A. & M. College, Miss.; Vice-Chairman, Herbert Spencer, Albany, Ga. For Secretary-Treasurer (3-year period), Oliver Snapp, Fort Valley, Ga. By motion and vote the report was accepted and the officers duly elected by casting a single ballot.

Upon motion of the Secretary, the Branch voted to hold its next annual meeting cojointly with the parent Association in New Orleans, Louisiana, next December, and to hold an adjourned meeting with the Association of Southern Agricultural Workers in Birmingham, Alabama, the first week in February, 1932.

PART II. ADDRESSES AND PAPERS

The session for addresses and presentation of papers convened immediately following the business session with Chairman Robinson presiding.

Annual Address of the Chairman, J. M. Robinson, Auburn, Alabama.

THE TREND IN ENTOMOLOGICAL ACTIVITIES IN THE COTTON STATES

By J. M. ROBINSON, *Entomologist, Alabama Agricultural Experiment Station, Auburn, Alabama*

ABSTRACT

The trend in entomological activities in the Cotton States today is toward improved facilities for fundamental research, more protection from introduced species of insects, better methods for the dissemination of insect control information through the extension entomologist, and improved and enlarged facilities for the training of entomologists in the various institutions of higher learning, particularly in the land grant colleges.

There are four major entomological activities attracting the attention of the thinking people in the Southern States today, namely, research, quarantines, extension, and teaching. These groups of activities serve the people in different ways and obtain their support in proportion to the service rendered and the publicity given them.

RESEARCH. The background for the need of research, in the Southern States, had its beginning when "Edmund Ruffin in 1874, a Virginian, and a man of vision, and high rank in agriculture, wrote upon the damage done by the Angomois grain moth in the American Agriculturist," L. O. Howard, History of Applied Entomology, p. 12. Even in that early day, the resistance to insect damage and the search for an immediate control was desired. We are still using practical controls without understanding many of the underlying principles. The great arm of research with its two branches, the fundamental and applied, has gone a long way in the past half century toward the refining of ways and means to reduce the losses from insects.

The fundamental entomological research has lagged, while the applied has necessarily surged ahead. The practical struggle for existence has forced the use of artificial controls ahead of natural and has in a measure overshadowed the feeling that fundamental research was imperative. Today, we have the entomological research programs of the agricultural experiment stations that are broad and varied. A glance at the classified list for 1930 reveals the fact that there are sixty-three projects definitely listed as working toward biological studies and control measures, five projects are ecological in content, two each are studying insecticides and beekeeping, and one each has to do with distribution, effect of insecticide on the host, and insect physiology. Of the seventy-five (75) projects listed, only nine and three-tenths (9.3), roughly ten per cent of them specifically indicate from their titles that the research project has been projected from a strictly fundamental point of view.

We are still facing the bold fact that our problem as State workers is to look toward the immediate practical rather than devote the time, thought, and money to the really fundamental research to answer the many "why" questions of our multitudinous native species. In looking over the list of active projects of the Bureau of Entomology in the Southern States, it is evident that the ratio of fundamental to applied projects is quite similar to that of the state experiment stations. The fact that some states are beginning to support fundamental research, along with the more practical work, indicates that the appreciation of such work is winning its way with administrators. Is it not time to increase the ratio in favor of fundamental research?

In the field of natural control with parasites, either plant or animal, there is ample room for further fundamental research. *Trichogramma minutum* Riley is receiving considerable attention and some progress has been made. To what limit may the effect of this parasite and many others be extended in fighting our insect battles?

Further expansion of research facilities has been provided as the significance of such work has gained favor. The establishment of entomological field stations by the United States Bureau of Entomology is an activity that has been advancing for several decades. Today, the entomological research field station has become another working tool of the entomologist connected with the state experiment station. Even the agricultural sub-stations are beginning to provide entomological research facilities.

QUARANTINES. Obtaining maintenance for fundamental research has been a much more difficult task than getting similar assistance for other phases of insect control activities. For example, who anticipated the possibility of obtaining $10,000,000 to perhaps check the advance of one imported insect when Dr. C. L. Marlatt engineered the passing of the Plant Quarantine Act of August 20, 1912? The modus operandi of quarantining, scouting, and eradicating the introduced species has had many and varied experiences. The original purpose of the above mentioned act was to protect the American agricultural plant industry from the ravages of pests from foreign countries. The laws have grown by amendment to cover domestic and inter-state movement of materials that might be carriers of pests. Today the work of the United States Department of Agriculture Plant Quarantine and Control Administration and that of the various State Plant Boards tops all entomological work in its appeal to the public mind for appropriations. The spirit of fight and the feeling of danger perhaps makes it possible to obtain funds to reduce the damage of a common foe.

The quarantine, scouting, and eradication system of combating introduced insect species has been developed and systematized to the point where the work stands as a separate unit. Its methods of eradication are so diabolical that the job of suppressing the "Med-fly" in Florida has approximately approached "eradication" proportions in a much shorter time than might reasonably have been expected. This statement is of considerable importance when compared with previous attempts at eradication of introduced species.

The spirit of continuing the fight against the common insect foes is not at all latent. There are many imported and native pests that continue to irritate the laity, as well as the professional entomologist. Some of the imported forms are to be discussed on this program. What shall we do about the mosquitoes? Surely they are still a menace to the health of our population. In fact, death due to malaria in Alabama in the past three years has varied from 204 in 1927, 291 in 1928, to 430 in 1929. These figures become the more significant when it is recalled that the estimators say that one-half of one per cent of the cases die. Turn these figures around by multiplying 430 deaths by 200 and you have an estimated population of 86,000 cases of malaria in 1930 in one Southern State. Actually, there were 10,476 cases reported. The rainfall in 1929 was the greatest in fifty-one years, and, therefore, the natural condition was unusually favorable for the development of native mosquitoes. And where is the drive to relieve the householder of the termite, cockroach, and the many other insect problems?

The cooperation of Federal and State forces in quarantine work has developed to such an extent that a foreign insect has a small chance of making much headway within our borders before it is discovered. Appropriations are fairly quickly made available to locate the extent of the distribution and to provide methods of attack to suppress, with the idea of eradicating the newly introduced pest. The Federal and State inspectors stand guard at the border stations and at ports to see that agricultural products are protected from foreign invasion.

EXTENSION. The extension entomologist is the most recent addition to the list of those working in the field of economic entomology. This particular species of entomologist has come about because of the great expansion in Smith Lever work, and a need for what extension people call subject matter specialists. The South has developed in this line of entomology as well as in all others. Today every Southern State has one or more specialists in entomology. The primary duty of the extension entomologist is to keep the county agricultural workers informed on the most up-to-date methods of control for any and all pests that might

occur in this territory. The other duty of the extension entomologist is to teach adult farm people how to combat insect pests, and how to protect and encourage the development of insect friends.

There are many ways of getting the desired information before the people. Probably the most effective means is by the use of newspaper articles. The field demonstration of course is the foundation of extension work and a great deal of information radiates from any good demonstration. Circulars, bulletins, radio addresses, and personal correspondence are all used by the extension entomologist in carrying on his work.

The control of cotton insects, insects of the garden and orchard, insects attacking stored grain, and insects attacking man and domestic animals is the basis for most entomological demonstrations in the South. Apiculture is also an important project in most of the Southern States.

TEACHING. From whence come these men that govern the destinies of Entomological Activities in the Cotton States? In times past many of them have been the products of institutions of higher learning outside the Cotton States. It is indeed animating to note that in the past decade there has been a movement to encourage the southern college student to specialize in the entomological field within our southern institutions.

When we stop to observe that provision is being made for undergraduates to take special courses in the field of entomology, and with further glance we see the master's degree work being offered from Florida to Tennessee and from Texas to Maryland, we can really take heart and feel that in a measure the institutions of the South are giving ear to the training of entomologists.

Would it be too much to predict that the land grant colleges, as well as other institutions of higher learning, will soon be training men under southern conditions even to the doctorate in the special field of Entomology? One further step in providing more trained men to our teaching staff and the provision of adequate library facilities will place the South on a par with other sections of our nation.

Is this the opportune time to think seriously on this subject and make resolutions in that direction?

As a parting word, permit me to express the hope that we will girdle our determination about our will to achieve and press onward with the work which it is our good fortune to promulgate at the present time.

In discussing this address, F. C. Bishopp called attention to malaria in the South and the need for southern entomologists to give more attention to medical entomology. He pointed out a field of work for extension entomologists by stating that in medical education physicians should receive assistance from the entomologists.

THE PRESENT STATUS OF THE PINK BOLLWORM IN THE SOUTHWEST

By R. E. McDONALD

ABSTRACT

This paper discusses the present distribution of the pink bollworm (*Pectinophora gossypiella* Saund.) in Mexico and the southwestern part of the United States, and the intensity of the infestation in each area as revealed by the mechanical inspection of gin trash. The effect of low winter temperatures in a large part of the infested area on control of the insect is mentioned. It summarizes the efforts made to eradicate the rather heavy infestation discovered in the eastern end of the Salt River Valley of Arizona in the fall of 1929, by means of cleanup operations, a non-cotton zone, and delayed planting dates in the restricted zone, and details some of the difficulties encountered due to the subtropical climate of that area. The results of these efforts are reviewed, and the program for the 1931 campaign is outlined. This provides for winter cleaning, plowing, and irrigation of all cotton fields within approximately three miles of infestation, the prevention of growing volunteer cotton, and the delaying of planting until the peak of moth emergence has passed. Mention is also made of the scouting done in Mexico in cooperation with the Mexican Department of Agriculture, to determine the distribution of the pink bollworm on cotton and wild host plants.

The pink bollworm has existed in the upper part of the Valley of the Rio Grande of Texas, Mexico and New Mexico for several years, and likewise in the Valley of the Pecos in western Texas and New Mexico. In the cotton growing areas of Presidio and Brewster Counties in Texas and in adjacent Mexico, infestation has built up to the point where it does considerable damage, readily perceived and felt by the growers. In some fields practically all late bolls are infested. This cotton area is located on the Rio Grande in the southern edge of what is known as the "Big Bend". The country is reached by very few roads, and the cotton fields are from 50 to 100 miles away from the Southern Pacific Railway and the Borderland Highway, running east and west. This isolation has made comparatively easy the enforcement of quarantine measures to prevent the exit of cotton products.

In the other areas mentioned, the pest has not yet done any noticeable damage. The infestation is general but light. This apparent control is due largely to seed disinfection and cleaning of points of concentration. It appears that these measures will hold in check an infestation of the pink bollworm if started before the pest gets a foothold and if aided by very low winter temperatures. The areas under discussion, except the "Big Bend", frequently have weather approaching zero, but in the Big Bend twenty above is considered low.

In 1927 the pink bollworm was discovered over a large section in western Texas, on the western extremity of the main cotton belt from Big Spring, westward. Several Counties were involved, aggregating about 400,000 acres of cotton. The area was placed under strict supervision for a period of three years. In the beginning, all cottonseed was brought from the farms and sterilized or milled, and gins and other points of concentration were cleaned up. Subsequently, all seed was sterilized as a continuous process of ginning and all gin trash disposed of promptly and the lint was all fumigated. These measures, aided by the very cold winters and the usual lack of debris in the cotton fields, together with complete absence of volunteer cotton, have resulted, apparently, in eradication of the pest from a large part of the area involved. After the initial infestation, no specimens were taken farther east than Midland, Texas, although an exceptionally large amount of inspection has been done, especially in the 1930 crop. Hence, the area east of Midland, Texas, was released after the crop season of 1930. One specimen of *Pectinophora* was found near Midland, Texas, in the 1930 crop and several specimens in Ector and Andrews Counties, directly west.

In the fall of 1929 a comparatively heavy infestation of the pink bollworm was found in the eastern end of the fertile Salt River Valley of Arizona. When discovered, a comparatively small area of some four or five sections was infested to the extent of fifty to seventy-five per cent of the green bolls. From this focal point it gradually became lighter and in a distance of about six miles it apparently dwindled out entirely. On account of the density of the infestation, it was decided that the best procedure of eradication of the insect would be to establish a non-cotton zone. This was done, including an area two miles beyond the outermost point of infestation. This zone was then surrounded by a restricted zone three miles in width, in which the practice of stubbing cotton was prohibited by State order and the planting of cotton delayed for Pima until April 1st or later, and Upland until April 20th or later. All the fields, amounting to about 40,000 acres, were cleaned thoroughly; first, mowing the stalks, horse-raking and burning them; second, hand-raking; and, third, by picking up the remaining cotton remnants. This work was started February 27th and finished April 30th. By the time the field cleaning was finished, the stubs had begun to sprout and even were in fruit. It was necessary immediately to plow the whole area in order to destroy this stub cotton. Subsequent to that, it was necessary to go over the ground several times with hoes and dig up the remaining sprouts coming from buried roots.

The Salt River Valley is subtropical; cotton is often produced several years without replanting. This stub cotton sprouts early in the spring and is in fruit almost by the time other cotton is up; hence, it constitutes a great handicap in controlling or eradicating the pink bollworm. It is exceedingly difficult in the Salt River Valley to prevent cotton sprouting from the roots. Fields plowed by the ordinary methods will be found to have considerable cotton which is not killed.

Undoubtedly, the climate and the cotton growing practices in this locality are ideal for maximum damage by the pink bollworm. The winter temperature seldom, if ever, gets low enough to offer any measure of control. The growing season is long. Sprout cotton is ordinarily fruiting profusely by April 1st. From this date the propagation of the insect may continue without interruption until the following December. Even though the practice of stubbing cotton should be discontinued by the growers, it will require energetic and diligent efforts to prevent the sprouts growing on any lands in cotton the previous year, whether plowed or not.

In the fall of 1930, examinations revealed the fact that very light infestations existed in several other parts of the Salt River Valley, involving much more acreage than that with which it was necessary to contend during the crop year of 1930. In addition, considerable light infestation was discovered on the Gila River near Coolidge and Casa Grande, some 50 miles south of the Salt River project, and climatically similar. Under the old system of field inspection only a few of these infestations in the 1930 crop would have been discovered. A very large amount of field inspection failed to reveal several of them, even after they were discovered through the medium of the mechanical detector. Therefore, had it not been for the mechanical detector, we would have likely been deceived as to the true condition of infestation. Of course it is not definitely known how the insect spread from the initial infestation to these other spots, but it had opportunity to do so through the movement of pickers and otherwise prior to the time eradication measures were instituted.

On account of the light nature of the infestations, it is believed that at least some of the infested spots may be eliminated by careful cultural control methods, applied immediately and vigorously. A modified program, therefore, has been adopted for the season of 1931, which provides for the winter-cleaning, plowing and irrigation of all cotton fields within approximately three miles of infestation, the prevention of stubbing in such areas, and the delayed planting to April 1st for Pima and April 20th for Upland.

Pima cotton is an Egyptian variety which requires a longer growing season than American Upland; planted April 1st it will come into fruiting about the time that Upland will if planted April 20th. This fruiting date of cotton so planted will undoubtedly be beyond the peak of emergence of moths of the pink bollworm in that locality.

In the spring of 1930 careful tests were carried out in connection with the eradication program to determine the behavior of pink bollworms which were not destroyed by the cleaning of the fields. A soil-screening machine was set up that separated the worms which were hibernating in the ground. This apparatus was run into July. Flight-screens and light-traps were kept in operation during the same period. Also trap-plantings of cotton were maintained, from which the fruit was picked as it might become infested but before the insect could be propagated. All these tests indicated that the peak of emergence was considerably prior to the fruiting period of cotton planted, as mentioned above. While none of the tests indicated any emergence late enough to carry infestation into the cotton planted on the dates mentioned, yet it is believed that there is a small per cent of delayed emergence. This conclusion is borne out by more comprehensive records from other localities. Therefore, in case of heavy infestation, this procedure would not likely offer any hope of eradication. However, when we are dealing with infestations so much attenuated, there is a very strong probability that at least some of them will be eliminated by careful adherence to the program outlined. The area in the Salt River Valley which was in a non-cotton zone in 1930 has been released for planting on the same dates as required in the above described restricted area. This will give two emergence seasons for the long-cycle larvae in this area, which, in conjunction with the careful clean-up program carried out, is believed to be sufficient to effect eradication. It is now hoped that in one or two years, by following up the practices thus laid out—non-cotton zones over heavy infestations and careful restrictions on light infestations, that eradication may be finally accomplished.

By the use of mechanical detectors, infestation was discovered with comparative ease at practically all gins in the quarantined area except around Big Spring, Texas, which was mentioned above as being released. This shows a rather uniform distribution of the pink bollworm throughout the Pecos Valley in Texas and New Mexico and in the Rio Grande Valley north of the Big Bend area in Mexico, Texas and New Mexico, practically as far north as cotton is produced. The following listings of gin trash inspections for the season of 1930 give a very good picture of the distribution and intensity of the infestation:

County	No. Bushels of Trash Inspected	No. Specimens Found
Texas		
El Paso	1,618	119
Hudspeth	409	6,918
Reeves	213	11
Midland	4,174	1
Ward	391	2
Presidio	48	53,087
Dawson	15,782	x
Howard	6,676	x
Martin	8,079	x
Pecos	151	x
	37,541	60,138
Arizona		
Maricopa	17,680	1,240
Pinal	3,690	31
Pima	1,236	4
Graham	1,956	3
Greenlee	29	x
	24,591	1,278
New Mexico		
Eddy	2,230	20
Luna	55	19
Dona Ana	1,458	42
Chaves	1,476	3
Otero	44	1
	5,263	85
Total for season	67,395	61,501

Negative inspections to this time for the season of 1930 are quite encouraging. A large amount of work has been done in the western part of Arizona and California, in the Lower Rio Grande Valley of Texas and adjacent Mexico, and in the western border of cotton growing in Texas, all with negative results. Approximately 10,000 samples of 100 green bolls each, have been collected from the various States, from the Carolinas westward to Texas, preserved in a formalin solution. These are now being inspected by laboratory methods in San Antonio, Texas, which job will be completed by August 1st.

In cooperation with the Oficina Federal para la Defensa Agricula of the Republic of Mexico, during the past two years a survey has been made down the west coast, where cotton is grown at various points as far south as Nayarit, and no trace of the pink bollworm was discovered. In Mexico, east of the main backbone of the Rocky Mountains, a heavy infestation exists in the Laguna District, some 200 miles south of the Texas border and also in the cotton fields of the Rio Grande Valley near El Paso, Texas, and near Presidio, Texas. A rather careful survey has

been made in that part of Mexico adjacent to the Gulf of Mexico in the States of Nuevo Leon and Tamaulipas, which shows negative on both domestic and wild cotton. In the northern part of Mexico, in the States of Chihuahua and Coahuila, and to some extent in other States, there is a wild plant related to cotton, *Hibiscus cardiophylus*, which is a host of the pink bollworm and considerably infested in the Campana Mountains near Tlahualilo; also infested plants were discovered near Sierra Mojada, some 100 miles north. In addition, another wild plant, *Abutilon hypoleucum*, was found infested near Quatro Cienegas, approximately 100 miles northeast of the Laguna. It is believed, however, that these plants would not constitute a very serious handicap in Continent-wide eradication of this pest should this procedure at any time be decided upon. Because of secretions on the fruit, considerable numbers of the young larvae perish before entering the buds. Furthermore, the fruiting dates of the two plants in question seem to have no uniformity but are dependent upon moisture conditions. Hence, in all probability, unless the pest should be better established on these plants than it appears at present to be, it could not survive in the absence of domestic cotton.

PRELIMINARY REPORT ON CONTROLLING PINK BOLLWORM IN TEXAS BY WINTER CULTURAL METHODS

By D. A. ISLER, *Assistant Agricultural Engineer, Division of Agricultural Engineering, Bureau of Public Roads* and F. A. FENTON, *Senior Entomologist, Bureau of Entomology*, in Cooperation with Texas Agricultural Experiment Station

ABSTRACT

This article discusses the results of two years' work, in Presidio, Texas, on the effects of plowing and of irrigation as measures of pink bollworm (*Pectinophora gossypiella* Saunders) control. The best control was obtained by thorough plowing followed as soon as practicable by irrigation.

The first experiments to determine the effect of burial and irrigation on mortality of the pink bollworm (*Pectinophora gossypiella* Saunders) of cotton in this country were carried out at Castolon in Brewster County, Texas, from December, 1927, to July, 1928, by F. A. Fenton.[1] These tests brought out the fact that certain combinations of burial and irrigation caused a very high percentage of pink bollworm mortality and indicated that further work along this line was necessary. In order that results obtained might be more comparable with those

[1]Fenton, F. A., 1929. Biological Notes on the Pink Bollworm in Texas. Trans. Fourth Int. Cong. Ent., Vol. II, pp. 439–447.

which would result in field practice, a series of cultural-control experiments was started at Presidio in December, 1928, and has been continued for two years at this locality.

These cultural-control tests were similar to those in the study of hibernation in that both included variations of plowing or burial and irrigation, both separately and in combination. In 1928–29 the main factors considered were time of year and depth of plowing, and time of irrigation. In 1929–30, in addition to studying the effect of the above factors on control of the pink bollworm, a limited amount of work was done with reference to types of plows. The following is a report on results obtained after two years' work at Presidio, Texas.

Methods of Experimentation

The soils of this valley vary from the finest of sands to the heaviest of clays, or so-called adobe. In 1928–29 the experiments were carried out on two soil types—a sandy loam and a silty clay soil. In 1929–30 there were three soil types represented as follows: a sandy loam, a clay loam, and a silty clay.

In preparation for carrying out the work, the natural existing pink bollworm infestation was determined for each field or soil type used in the experiments. In all cases this was found to be so slight that it has been disregarded throughout, and it was therefore necessary to build up an infestation artificially. Material for accomplishing this was secured from heavily infested fields near Presidio. Just before placing the infested material on the plots an examination of a large number of boll samples was made in order to determine the live worm population per boll. Then the required number of bolls were counted to give the desired concentration of infestation. On the average, about 90 bolls were used per square yard.

In the first year's work, in all tests, winter irrigation was compared with spring irrigation and, as a check, a series of plots was left unirrigated. The plowing combinations used in the above-mentioned tests were: winter versus spring plowing with unplowed plots as checks. The plowing in each series was done at both 6 and 8½ inch depths. In the work of 1929–30, on the clay loam soil, both plowing and irrigation were carried out in various combinations as regards time of operation, on the first of each month from December to April, inclusive. Plots scheduled to be plowed on a given date were so arranged that they could all be plowed at the same time in a continuous strip. The plowing was done in one direction as it was inadvisable to throw backfurrows and dead furrows. The irrigations were all applied across or at

right angles to the plow plots. In this way a comparison could be made between any combination of treatments.

With the exception of December, 1928, before any work was started on the plots, all cotton stalks were cut, raked, and burned. In 1928–29 each plot was 50 by 100 feet, and in 1929–30 the dimensions were 30 by 50 feet. At the center of each plot an area 9 by 10 feet in extent in 1928–29, and 9 by 12 feet in 1929–30, was covered with a layer of in-

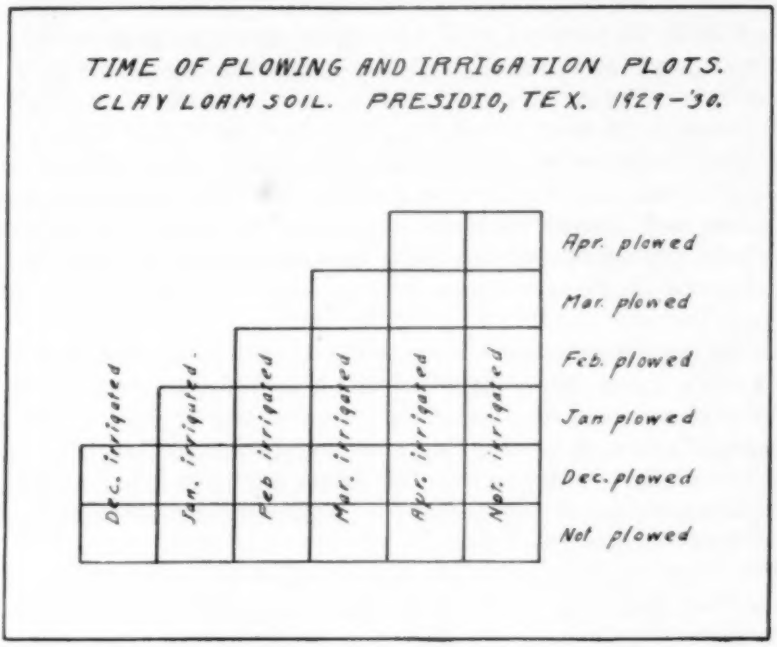

FIG. 56.—Chart showing plowing and irrigation data.

fested cotton bolls so distributed that the number of live larvae per square yard was known. In 1928–29 this averaged 250 per square yard, and in 1929–30 the average was 167 live worms per square yard (Figure 56).

There was somewhat of an artificial condition introduced into the project by the plowing under of an abnormally heavy layer of bolls, but this condition held throughout and any error should be reflected uniformly in all cases where plowing was at the same depth. (Plate 26). With less trash, a larger percentage of it should theoretically be buried deeper or closer to the plow sole. Therefore, results shown in this

work should be even more favorable as a control when applied to actual field conditions.

A tractor sulky plow equipped with a 14-inch general-purpose bottom, rolling coulter, and jointer was used with a Fordson tractor for the plowing of all plots except those in the type-of-plow series. The only soils in which this width of bottom was not entirely satisfactory were the heavier clay or adobe soils where scouring difficulties occurred, but rather than introduce the factor of varying the equipment used for the tests, the 14-inch bottom was used throughout. In the heavy clay soil, side draft in the plow could not be entirely eliminated with the equipment at hand and it was necessary to weight the rear of the plow in order to keep it running steadily and at an even depth. Pulverization was not as complete as desired, since on account of the heavy character of the soil the furrow slice was broken up into large lumps. This left the plowed surface very rough, with some tendency for the surface trash to be exposed between the lumps and also in the furrow creases. The clay loam and sandy soils were easily handled and only the usual hitch, coulter, and jointer adjustments were necessary to secure proper operation of the plow.

In the depth-of-plowing work only the 14-inch moldboard plow was used on the lighter sandy loam and the heavy silty clay soil. A poor quality of coverage resulted at the 4-inch depth of plowing in both these soils as was to be expected, but coverage was good at the greater depths. Six inches seemed to be about the minimum depth at which complete coverage of this quantity of surface trash could be expected with the 14-inch moldboard plow.

The type-of-plow series was conducted only during 1929–30 on a clay loam or medium type of soil. This series consisted of 4, 6, and 8 inch plowing with a Fordson side-disc plow, a 12-inch black land bottom horse-drawn sulky plow, and a 14-inch general-purpose bottom tractor sulky plow. The 12-inch sulky was a typical farmer's plow as commonly used without any accessories. This plow gave rather poor coverage at all depths and especially so at the 8-inch depth. The absence of a rolling coulter and jointer was very apparent from the rough, broken furrow wall and the trash left exposed between the furrow slices. The Fordson side-disc plow equipped with scraper cleaners gave a very incomplete job of coverage at the 4-inch depth of plowing, a poor job at 6 inches, and fair coverage at the 8-inch depth. The scraper cleaners, when kept adjusted as low as possible, tended to force the soil down and prevent the trash from being thrown out of the furrow.

Water for irrigation was pumped from the Rio Grande and an automatic water stage recorder and 2-foot rectangular weir were used for the measurement of water applied to the plots. From the results of former hibernation tests it appeared that the quantity of irrigation water used had very little influence on mortality, so a standard 7-inch irrigation was adopted for all waterings (Plate 27).

The effect of the various combinations of plowing and irrigation on mortality of the pink bollworm was checked by periodic examinations of bolls in screen cylinders set in the soil and by the installation of cages for records of moth emergence. In 1928–29, 2 square yards containing 500 larvae were caged per treatment for moth-emergence records. In 1929–30, 6 square yards containing 1,000 larvae per treatment were caged (Plate 27). The emergence of moths was recorded daily from April to June and these records represent the final index as to the effectiveness of the various treatments as measures of control. All data considered in this report are based on moth emergence.

Presentation of Data

Effect of Soil Type on Survival. Soil type has an important effect on the mortality of the pink bollworm. As shown in Table 1, the survival in the sandy soil has been extremely light for both years. In 1928–29 the percentage of survival in clay soil was 2.13 as compared with 0.2 for sandy loam. The next year the percentages were 0.126 as compared with 0.035. In taking up the cylinders for examination it was noted that buried bolls in the sandy soil had decomposed to a greater extent than those from either the clay loam or the clay soils. In the lighter soil, regardless of whether irrigation water had been applied or not following plowing, the buried bolls contained a relatively high percentage of moisture, while in the clay soil, when no water was applied, the bolls remained fairly dry.

Table 1. Effect of Soil Type on Survival of the Pink Bollworm, Presidio, Texas, 1928–30

Year	Soil Type	Number of Live Larvae Caged	Number of Moths Emerged	Per cent of Survival
1928–29	Clay	15,000	320	2.13
	Sand	12,000	25	0.2
1929–30	Clay	23,000	29	0.126
	Clay loam	44,000	161	0.366
	Sand	23,000	8	0.035

Effect of Irrigation Alone on Survival. During both years there were plots in which the bolls were not plowed under to serve as a

check for the effect of plowing. Since irrigation was also a factor being considered in connection with plowing, some of these surface-boll plots were irrigated. Thus by comparing the emergence from surface-boll plots unirrigated with that from the irrigated, the effect of irrigation alone as a factor could be evaluated. For the 2-year period there were 22 plots of surface bolls, of which five were never irrigated, three irrigated in December, three in January, three in February, five in March, and three in April. These plots were in three soil types. While individual variations were noted, the average for all plots in all soils for the two years (Table 2) shows that there was a survival of 0.87 per cent from the irrigated plots and of 0.77 per cent from the dry plots. This indicates that the added moisture by a 7-inch irrigation to surface bolls at Presidio was somewhat beneficial to the worms.

Effect of Plowing Alone on Survival. In order to determine the effect of plowing without the added effect of irrigation water, during both years a series of 15 plots were plowed at the various dates previously stated and left dry throughout the test. There were cases, especially in the sandy soil, where plowing increased mortality. As discussed later, some dates of plowing also caused a considerably lower survival than others, but a two-year average of all dry plots shows that for the two years at Presidio there was an average survival of 1.37 per cent from the plowed plots as compared to 0.77 per cent from the surface plots (Table 2). This indicates that, as a rule, plowing without the addition of moisture serves to protect the larvae from the temperature extremes of the soil surface and better enables them to survive. These data, however, may be applicable only in localities with temperature and rainfall conditions similar to those which prevail at Presidio.

Effect of Plowing and Irrigation in Combination on Survival. When plowing was followed by an irrigation as soon as possible, or within the same week, we find a very low percentage of survival in all cases. As a comparison with each of the 15 dry plowed plots discussed in the preceding paragraph, there was also a like number of plots plowed at the same time and in the same manner which, however, received, in addition, an irrigation immediately thereafter. Over the two-year period in all soil types with various dates of plowing and irrigation there was an average survival of 1.37 per cent from the 15 dry plowed plots, and 0.168 per cent from the 15 plowed irrigated plots, thus showing that plowing followed shortly by a 7-inch irrigation caused a decided increase in mortality of the pink bollworm (Table 2). In the individual plot records there were many instances in which no moth emergence was recorded.

Plowing under the layer of infested cotton bolls on an experimental plot.

Close-up of 14-inch moldboard plow passing through the boll layer.

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Irrigation of sandy soil plots.

Two 3-square-yard moth emergence cages installed on a plot, and two of the four screen cylinders as used for mortality determinations.

TABLE 2. SUMMARY TABLE OF EFFECT OF PLOWING AND IRRIGATION ON SURVIVAL OF THE PINK BOLLWORM, PRESIDIO, TEXAS, 1928–30

Treatment	1928–29 Number of Larvae Caged	1928–29 Number of Moths Emerged	1928–29 Per cent Survival	1929–30 Number of Larvae Caged	1929–30 Number of Moths Emerged	1929–30 Per cent Survival	Two-year Average Survival Per cent
Bolls left on surface—Dry (Check)	1,000	14	1.4	3,000	4	0.133	0.77
Bolls on surface, irrigated	2,000	30	1.5	13,000	31	0.238	0.87
Six-inch plowing in dry plots	2,000	47	2.35	11,000	43	0.39	1.37
Six-inch plowing followed immediately by irrigation	2,000	6	0.3	11,000	4	0.036	0.168
Six-inch plowing with irrigation delayed for one month after plowing	——	—	—	8,000	2	0.025	——
Six-inch plowing with irrigation delayed for two months after plowing	——	—	—	7,000	10	0.143	——
Six-inch plowing with irrigation delayed for three months after plowing	——	—	—	4,000	15	0.375	——
Six-inch plowing with irrigation delayed for four months after plowing	——	—	—	3,000	52	1.733	——

The effect of a delay in the application of irrigation water after the plowing had been done was studied in 1929–30 only. Moth emergence for this season was extremely light, but taking into consideration the large number of worms caged per treatment, averages have been used to establish trends. An average survival of 0.036 per cent was recorded from the eleven plots plowed and irrigated immediately; 0.025 per cent, or slightly less, from the eight plots in which irrigation was delayed one month; 0.143 per cent from the seven plots with a two months' delay; 0.375 from four plots with three months' delay; and 1.733 per cent from three plots in which irrigation was delayed four months (Table 2). These figures show that, on an average, if irrigation is delayed longer than one month after plowing, there will be an increase in survival with successive increases for additional lengthening of the period of delay.

Effect of Time of Plowing on Survival. A summary of the effectiveness of the various dates of plowing is given in Table 3. Here it might be well to mention that ordinarily plowing in December is exceedingly early for field practice, as in many cases cotton picking is still in progress at this time. April plowing is also a very late date from a practical standpoint. These two dates were included, however, to extend the work into extremes at either end, in order that other dates might be more forcibly evaluated. In the dry plowed plots early winter plowing was characterized by a much higher survival than that done in February, March, or April (Table 3). The March plowing, as represented on three soils in 1929–30, showed no moth emergence. Emergence from the February and April plowed plots was also very low. The high survival in early plowing indicates that the larvae were covered and protected from normal winter kill, which is indicated in the low survival of the plots plowed later, in the spring. In those plots where irrigation immediately followed plowing in 1928–29, we find a slightly lower survival in the two plots which were treated in March than in those plowed and irrigated in January (Table 3). In 1929–30 there was very little difference in effectiveness as regards the date of plowing when followed as soon as possible by irrigation, all dates producing almost 100 per cent mortality. The most complete control can be expected whenever plowing is delayed as late as possible, in order to secure the full effect of natural winter mortality, and then followed as soon as possible by an irrigation.

Effect of Depth of Plowing on Survival. From results in hibernation tests where bolls were actually buried by hand at specified

TABLE 3. EFFECT OF DATE OF SIX-INCH PLOWING ON PINK BOLLWORM SURVIVAL, PRESIDIO, TEXAS, 1928-30

		1928–29			1929–30		
		Number of Larvae Caged	Number of Moths Emerged	Per cent of Survival	Number of Larvae Caged	Number of Moths Emerged	Per cent of Survival
Date of plowing in dry plots	December	———	—	—	3,000	35	1.166
	January	1,000	43	4.3	1,000*	5	0.5
	February	———	—	—	3,000	2	0.066
	March	1,000	4	0.4	3,000	0	0
	April	———	—	—	1,000*	1	0.1
Date of plowing, irrigated immediately after plowing	December	———	—	—	3,000	0	0
	January	1,000	4	0.4	1,000*	0	0
	February	———	—	—	3,000	2	0.066
	March	1,000	2	0.2	3,000	2	0.066
	April	———	—	—	1,000*	0	0

*Clay loam soil only.

depths, it has been shown that an increase in depth of burial decreased per cent of survival progressively as the depth of burial was increased and indicates what should theoretically be expected in varying the depth of plowing. However, as is later shown, these trends were not always substantiated in the plowing experiments. In the 1928–29 depth series, 6 and 8½ inch plowing was done on both soils, sand and heavy clay, in January and in March, with a total of twelve plots plowed 6 inches deep and twelve plowed 8½ inches deep. In these plots the various combinations of irrigation were also included. The same plow, a 14-inch tractor sulky, equipped with a general-purpose bottom, was used throughout in the depth series. In emergence records from the individual plots, the effect of soil type on survival is noted. The 8½-inch plowing on an average was more effective in reducing survival on the sandy soil than the shallower depth (Table 4). The reverse was true, however, in the case of the heavy clay soil, where on an average, a greater survival was noted from the deeper plowing than from the shallower. In the January plowing on the heavy soil, a poor quality of trash coverage was secured at either depth owing in part to the presence of cotton stalks, a heavy layer of loose bolls, and scouring difficulties. Conflicting records appear in the emergence from these plots and indicate, in some individual cases, that the deeper plowing was also more beneficial in the clay soil. The average of the 24 plots representing the two extremes as regards texture of soil, in the conditions as represented at Presidio, in 1928–29, show that 6-inch plowing was more effective than the 8½-inch plowing (Table 4).

In 1929–30, six plots on each of the three soils, clay, clay loam, and sand, were represented at all three depth variations. In this year's work the effect of time of plowing was eliminated, all work being done February 28 to March 4, and the same plow was again used for all comparative tests. The number of infested bolls used per square yard was considerably less for this year than in the previous one, with the idea of reducing any error in departure from the normal action of the plow under average conditions, caused by a heavy concentration of surface trash. The error was probably not entirely eliminated. The average survival of March plowing for 1929–30 at Presidio, although emergence was very light, shows that 6-inch plowing produced the most effective control, there being an average survival of 0.033 per cent from these plots as compared to 0.083 per cent from the 8-inch plowed plots and 0.116 per cent from the 4-inch plowed plots (Table 4).

TABLE 4. EFFECT OF DEPTH OF PLOWING ON PINK BOLLWORM SURVIVAL IN ALL PLOTS AT PRESIDIO, TEXAS, 1928–30

Year	Depth	Soil	Number of Larvae Caged	Number of Moths Emerged	Per cent of Survival	Average Per cent of Survival
	6 inch	Clay	3,000	59	1.966	
		Sand	3,000	8	0.266	
1928–29	Totals and average...		6,000	67		1.116
	8½ inch	Clay	3,000	95	3.166	
		Sand	3,000	6	0.2	
	Totals and average...		6,000	101		1.683
		Clay	2,000	3	0.15	
	4 inch	Clay loam	2,000	4	0.20	
		Sand	2,000	0	0	
	Totals and average...		6,000	7		0.116
		Clay	2,000	1	0.05	
1929–30	6 inch	Clay loam	2,000	1	0.05	
		Sand	2,000	0	0	
	Totals and average...		6,000	2		0.033
		Clay	2,000	3	0.15	
	8 inch	Clay loam	2,000	2	0.10	
		Sand	2,000	0	0	
	Totals and average...		6,000	5		0.083

EFFECT OF TYPE OF PLOW ON SURVIVAL. The factor of type of plow used was studied, as previously mentioned, only on a clay loam soil and in the season 1929–30. An attempt was made here to compare a plow which would produce as good coverage as possible with both an average farm plow and a disc plow. It is noted in Table 5 that effectiveness of the type of plow used was correlated with the depth at which plowing was done. The 14-inch plow in the two plots used for each depth showed a lower survival at the 6 and 8-inch than at the 4-inch depth. The 12-inch plow showed very good results at the 4 and 6-inch depths of plowing, but poor results at an 8-inch depth because at the latter depth the furrow slice was left more edged and more bolls were left exposed in the furrow creases. The use of the disc plow gave much lower survival at the 8-inch depth than at either of the shallower depths and indicated that plowing must be deeper with a disc plow than with the other types, in order to expect the most effective control. An average of the three types as used at Presidio in 1929–30 indicates that, on the whole, more efficient results can be expected from a wide bottom plow than from the smaller bottoms and that a moldboard

plow is somewhat superior to a disc plow. A study of depth of plowing or types of plows is complicated by a number of factors such as soil types, soil tilth, locality, type of surface trash, and the innumerable designs of moldboard bottoms and disc plows. Quite an elaborate and extensive outlay would be required to cage a sufficient area so that moth emergence would be great enough to show the effect of the various combinations on a field basis. In case good plowing is established as an effective measure in control of the pink bollworm, then more detailed studies of these phases must be undertaken. It follows then that the plow must be selected according to soil and local conditions and properly operated to secure efficient and complete coverage.

TABLE 5.—THE EFFECT OF THREE TYPES OF PLOWS ON PINK BOLLWORM SURVIVAL IN A CLAY LOAM SOIL, PRESIDIO, TEXAS, MARCH, 1930

Type of Plow	Depth of Plowing	Number of Larvae Caged	Number of Moths Emerged	Per cent of Survival
14-inch tractor sulky plow	4 inch	2,000	4	0.2
	6 inch	2,000	1	0.05
	8 inch	2,000	2	0.1
Totals and average		6,000	7	0.116
12-inch horse-drawn sulky plow (no accessories)	4 inch	2,000	1	0.05
	6 inch	2,000	2	0.1
	8 inch	2,000	7	0.35
Totals and average		6,000	10	0.166
Tractor side-disc plow	4 inch	2,000	7	0.35
	6 inch	2,000	5	0.25
	8 inch	2,000	1	0.05
Totals and average		6,000	13	0.216

SUMMARY

Pink bollworm survival from all treatments was much lower in 1929–30 than in the preceding year at Presidio and for both years was markedly lower in light soils than in the clay soils. A high natural mortality occurred in breeding material left undisturbed on the surface.

Irrigation alone of surface trash gave no control but rather increased larval survival over that left dry.

When no irrigation water was applied, early winter plowing increased survival, while late spring plowing decreased survival to some extent.

Plowing followed as soon as possible by irrigation gave very good control with very little difference shown between the various dates of

plowing and irrigation. When irrigation was delayed longer than one month after plowing a gradual increase in survival was noted for each increased period of delay.

The most effective control seemed to result when plowing was delayed as late in the spring as possible, securing the maximum effect of natural winter mortality, and was then followed by an irrigation.

In the plowing experiments in the two years' work, as a whole, 6-inch plowing, with the plows used, was more effective than either 4-inch or 8-inch plowing.

The wider bottom moldboard plow was more efficient on an average than the narrower bottom and the disc plow used gave the least effective results.

DAMAGE TO COTTON BY CRICKETS

By J. W. FOLSOM, *Senior Entomologist, Bureau of Entomology*

ABSTRACT

Much new information is here presented on the field cricket (*Gryllus assimilis*) as a cotton insect. Results of observations and experiments on habits, life history, and methods of control are given.

The field cricket, *Gryllus assimilis* Fab., var. *pennsylvanicus* Burm., was unusually abundant and locally destructive to cotton in Madison Parish, Louisiana, in the season of 1930. This outbreak, at the home of the Delta Laboratory, gave us an opportunity to study the life history and habits of this cricket in relation to the cotton plant, and to experiment with methods of control. The most important results of the season's studies are given here.

Almost all these results are new, for this cricket has hitherto been almost overlooked as a cotton insect. Probably this common insect has been injuring cotton more or less every year, and its work on the plant has been disregarded or else attributed to other insects.

HISTORICAL. A note by Dr. C. V. Riley (1888. Insect Life 1: 87) refers to a species of *Gryllus* as "doing irreparable damage to cotton, sweet and Irish potatoes, peas, and tobacco" in Jena, Catahoula Parish, Louisiana, in May, 1887. He recommended poisoned bran mash as a means of control.

Prof. G. A. Dean (1915. JOUR. ECON. ENT. 8: 223) reported *G. pennsylvanicus* as being unusually abundant in many parts of Kansas in the summer of 1914, when the crickets entered houses and stores, and damaged curtains, clothing, fabrics, and rubber goods. He found that the

most practical and effective method of destroying them was by means of poisoned bran mash.

Prof. J. W. McColloch (1915. JOUR. ECON. ENT. 8: 308), while observing a flight of termites at Manhattan, Kansas, on October 6, 1914, noticed a cricket (*G. pennsylvanicus*) feeding on the termites as they emerged from the ground.

Snapp and Stafford (1918. JOUR. ECON. ENT. 11: 480) at Deeson, Miss., in September, 1918, found *Gryllus assimilis* Fab., var. *luctuosus*[1] Serv. (unusually abundant that year) damaging cotton during the night by "combing away the lint from the upper seeds in the newly opened bolls, cutting away the seed hull and eating out the contents."

Prof. J. R. Watson (1917. Bull. Fla. Exp. Sta. 134: 107) recorded *G. assimilis* as an enemy of strawberries.

E. A. McGregor (1929. U. S. Dept. Agr. Circ. 75) gave an excellent account of this species as a cotton pest in California.

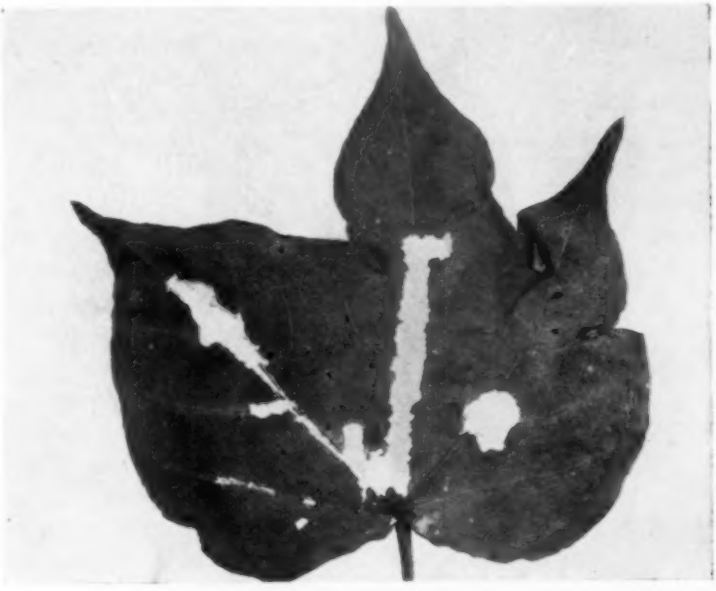
The following notes on the occurrence of *G. assimilis* during the season of 1930 are from the Insect Pest Survey Bulletin.—Abundant in Montana, May 20, W. B. Mabee; Massachusetts, July 28, J. V. Schaffner, Jr.; Nebraska, Sept. 1–Oct. 15, M. H. Swenk; Mississippi, Sept. 16, Oct. 22, R. W. Harned. In North Dakota, overwintered nymphs were observed on May 21 by J. A. Munro. In Montana these crickets ate wheat, and in Mississippi they destroyed alfalfa.

DAMAGE AT QUEBEC, LA. The worst damage in Madison Parish, Louisiana, was concentrated on the plantation of Mr. W. H. Sistrunk at Quebec, where the injury was first noticed during the first week of July. On July 17 this planter brought in to the Delta Laboratory specimens of injured cotton plants which "had us all guessing" as to the cause of the injury. He was advised to watch his fields at night. So that night he put men with headlights into the fields. They found great numbers of crickets working on the cotton plants, and Mr. Sistrunk himself made accurate observations on the feeding habits of the crickets.

At that time there had been no rain for more than two months; the soil, of the kind known as "buckshot," was baked and cracked and the plants were not growing much. Had it not been for the drought, the plants could have put out new leaves and outgrown the damage by crickets. As it was, rain came on August 15—the first since early in May—and a heavy rain on August 18, after which the plants picked up rapidly. On September 29 they looked as if nothing had happened to them, but the yield of cotton had been reduced. By November 19 un-

[1]Synonymous with *pennsylvanicus* Burm.

Damage to cotton by crickets. A row of leaf-fragments under a row of cotton plants.



Cotton leaf showing holes eaten along course of veins by crickets.

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infested land had made three-eighths of a bale per acre; similar but moderately infested land, two-eighths of a bale; and the most heavily infested areas, only one-eighth of a bale.

Incidentally, "millions" of these crickets invaded the village of Tallulah on several successive nights, particularly September 28 and 29. They swarmed under street lights and entered stores by thousands, causing alarm but doing no damage so far as could be ascertained.

CHARACTERISTIC DAMAGE. This cricket habitually cuts off fragments of cotton leaves and lets them drop to the ground, where they dry out. In addition, leaves partly eaten by the crickets during the night dry out in the hot sunshine and at length fall to the ground. The result, if the crickets are numerous, is an irregular row (Plate 28) of dried leaf fragments, with an occasional square or flower, on the ground under the plants on each side of a cotton row. These rows of pale yellow pieces of leaves, conspicuous against the dark soil, indicate damage by crickets.

The crickets eat holes in the leaves but have a pronounced habit of making holes along the courses of the main veins (Plate 28), which is also characteristic. A third habit is that of cutting the blades of leaves from their petioles, leaving the latter on the plants.

They gnaw into stems and squares and often eat out large holes in bolls. They eat the foliage in an irregular, haphazard manner, like grasshoppers and May beetles. Many small plants (6 or 8 inches high) that we observed had been defoliated or killed outright. On larger plants (1 or 2 feet high) only a comparatively small number of leaves had been eaten, and these were usually lower leaves.

All these kinds of injury that were seen in the field were found to be produced also by crickets on caged cotton plants in the field and in the insectary.

FEEDING HABITS. When the crickets came out of the ground after sunset they paid no attention to the cotton plants for two or three hours, but stayed on the ground. There they fed considerably on the dried fragments cut previously from cotton plants by the crickets themselves. They gnawed the edges or veins of these fragments and tasted fallen dried squares or flowers. Finally a few crickets could be found on the plants, where their numbers slowly increased. On green plants the crickets often gnawed the bracts of squares, ate round holes in squares, and nibbled blossoms. Their chewing was audible.

It was several times observed that a cricket working on a green leaf would perch himself on the upper surface of the leaf with his head toward the petiole and move backward as he ate out the leaf along

the course of a vein. The habit of severing blades from their petioles has been mentioned.

These crickets showed omnivorous habits. In the cotton field they fed to some extent on volunteer cowpeas, a pod of which often showed a row of holes where the cricket had eaten through the pod and hollowed out the seeds. In a mess of decaying bananas and oranges that had been thrown out in a cotton field several crickets were seen to be feeding on the bananas, which they eventually destroyed, but the oranges were not eaten.

One cricket was seen in town, under a street light, eating a moth. Crickets were observed eating dead or dying individuals of their own species, and the dead bodies of cockroaches and tiger beetles. In one instance a female cricket was seen feeding upon a still living cricket of the same sex, and had eaten a hole in the last three abdominal segments of her prey.

HABITS IN GENERAL. Owing to drought the soil in cotton fields was baked and cracked. The crickets were down in the cracks during the daytime. By digging they could be found, often only 2 or 3 inches from the surface, but when exposed they at once followed the cracks downward to depths of a foot or more. At dusk they began to emerge, and when it was dark they issued in constantly increasing numbers. They walked about on the ground, running or hopping away, or dodging under clods when disturbed, meeting one another, chirping, courting, and feeding on the fallen fragments of cotton plants. Not until late at night did many of them go to the plants.

For observing the nocturnal habits of the crickets flashlights were used. The crickets reacted negatively to the stronger rays but were undisturbed by the weaker ones. For a while before sunrise the crickets continued their activities and could be observed without the aid of artificial illumination, but at sunrise, or within half an hour thereafter, they disappeared into the ground. In small cages over potted cotton plants in the insectary and in large cages over plants in the field there was so much shade that the crickets were active during daytime, and could easily be observed.

STRIDULATION. The stridulation of this species is by no means obtrusive; the notes are subdued, thin, and rather weak; and the chirpings of an individual are very intermittent and not long sustained. The so-called note is actually a noise, unassignable to any definite musical pitch. The stridulation is very rapid. One morning, between 4 and 5.30 a. m., many males were singing, but only a few were on the ground; most of them seemed to be chirping from cover, just below the surface

of the ground. Undoubtedly the stridulation is affected by several factors, particularly temperature and humidity, the effects of which we have not worked out.

MATING. The details of mating were often observed. The fullest of our notes on this subject are the following, made by H. B. Mills on August 7: "Specimens of this species kept in the office were observed several times throughout the act of copulation. The male has a special, rapid mating song which is rather wiry and high-pitched, with a continuous undertone to which at regular intervals (three or four times a second) are added strong clicking sounds, like the ticking of a watch. The whole body of the male vibrates during this song. As many as four females were seen approaching a male during this mating song and dance. The female mounts the male, who immediately stops his song and extends and contracts his abdomen until at the tip appears the small, opaque-white spermatophore. The tip of the abdomen is then pressed up against the base of the female's ovipositor and the spermatophore adheres to the latter. During this process the cerci of the male vibrate rapidly and he turns his head quickly to one side and then the other. The female dismounts with the spermatophore quite evident ventrally at the base of the ovipositor. One male was seen to back under a female that was slow in receiving his advances, and then to attach the spermatophore. Fifteen seconds elapsed (in the three cases timed) from the mounting by the female to her dismounting."

G. W. Davis added these notes: "On August 6, two crickets were observed mating. The male danced around the female and kept up a constant song, which seemed to be very different from the usual song of the cricket, having many more rasps per second and being slightly sharper in note. At first the female seemed indifferent to the advances of the male, but finally she mounted upon his back. Copulation took place with the female on top of the male; the male curving his abdomen up to meet that of the female. A small white sack appeared on the abdomen of the female when copulation was complete."

OVIPOSITION. The eggs of one female are not laid in one mass but are scattered a little in the soil, though sometimes two or three stick together.

"The female inserted her ovipositor its full length into the soil, then withdrew it slightly and deposited an egg. Without withdrawing the ovipositor entirely she pulled it up and reinserted it at a slightly different angle and deposited another egg. This operation was repeated several times. A very rapid swelling of the ovipositor, passing from the base outward, showed the passage of an egg" (H. B. Mills).

In oviposition the female "pushes the ovipositor into the ground at an angle of about 35° from the horizontal. She then pulls the ovipositor out about one-half its length, changes the angle slightly, and pushes it down again. After repeating this several (4 to 8) times she moves to a new place and repeats the process" (G. W. Davis).

Immediately following their last molts, three female crickets were mated with males and kept under observation, with the following results:

Cricket No.	Last Molt	Preoviposition Period Days	Maximum Number of Eggs in One Day	Total Number of Eggs Laid	Average Number per Day	Number of Days Under Observation
1.....	Aug. 2	5	21	142	7.8	23
2.....	Aug. 3	3	87	238	12.5	22
3.....	Aug. 7	4	13	37	2.6	18

EGG. The egg of this species is at first translucent lemon yellow in color, subcylindrical, rounded at both ends, straight or feebly curving, and smooth. Average length, 2.16 mm.; width, 0.47 mm. Two days after being laid the egg is dull whitish yellow. Three or four days before hatching the eye spots become visible through the chorion, and later on the antennae and body segments, and the egg becomes darker.

From 57 records the egg period was found to be: maximum, 16 days (July 30–Aug. 15); minimum, 9 days (Aug. 8–17); average, 11.7 days.

HATCHING. "At hatching, the nymph in the egg begins to move, and in a few minutes the chorion of the egg splits. The split occurs at the anterior end of the egg and runs longitudinally from the top of the head to the abdomen. The nymph emerges by a series of wave-like movements, beginning in the last segments of the abdomen and moving forward. After the head and front pair of legs are free the insect pulls itself out by means of the front legs. The young nymph rests from one to ten minutes and then begins to move about. In several instances that were observed the split of the chorion was too short to free the head of the nymph. The nymph managed to free its body but was forced to leave its head stuck to the chorion, and in almost every case died without being able to free itself" (G. W. Davis).

LIFE-HISTORY NOTES. In molting, the old skin split along the median dorsal line from the head to the abdomen, and the insect emerged head first, pulling the abdomen out of the cast skin, as it attempted to walk forward.

The length of the first-instar nymph averaged 2.21 mm. (2.0–2.5); second instar, 2.97 mm. (2.8–3.1); third instar, 3.5 to 4 mm.

The first instar averaged 5.3 days (4–7) in length, and the second, 7.2 days (5–10). We have no records of the length of the third instar.

The mortality of young nymphs (reared in Petri dishes) was great. Thus, of 208 nymphs 52 died during the first day after hatching, 48 died within two days, 27 within three days, 15 within four days, and 9 within five days. By November 6 only one nymph had survived; it was then 84 days old.

In the insectary, of 177 eggs that hatched, 62 per cent hatched on August 11 or 12.

Out of doors the number of adults gradually decreased as the new generation came along, and by August 28 only 30 per cent of the crickets counted were adults.

The crickets of the new generation were only about half grown when winter arrived. After rains had closed the cracks in the soil young crickets dug burrows in the ground, although many could always be found on the surface under shelter of various kinds. Out of doors (Nov. 19, 25, 28) burrows from 1 to 3 inches deep were found abundantly in the furrows in cotton fields. In many instances a burrow contained a nymph, but all the nymphs that were found were males.

Estimation of Infestation. After we found that the crickets, upon emerging from the ground after sunset, all remained on the ground for perhaps two hours or more, it became an easy matter to count them on a known area. Our practise was to count them on three successive rows for a distance of 250 feet; the rows being 3 feet 4 inches wide. That gave the number for 2,500 square feet, from which the number per acre was computed. The counts were begun at about 9 o'clock each night, by which time the numbers of crickets had become fairly constant.

Result of Plowing. At first Mr. Sistrunk plowed an entire field without, however, succeeding in reducing the number of crickets permanently. A surface cultivation on July 26, for the purpose of filling cracks in the soil, delayed the reappearance of the crickets for a time, but by August 1 they were as abundant as before, as was to be expected.

An experiment on the effects of plowing was made in a field of 5 or 6 acres, where on the night of August 1 there were 2,444 crickets per acre. August 2, the field was plowed. August 3, at night, there were 2,600 crickets per acre—an apparent increase in numbers.

Dusting. On July 18 some of us visited Mr. Sistrunk's plantation to study the infestation. Early in the morning of the next day we had one of his fields dusted by airplane with calcium arsenate at the rate of 8 pounds per acre. July 20 no benefit from the dusting was apparent,

but by July 22 the numbers of crickets were noticeably fewer; dead crickets and sick crickets were seen on the ground, and ants were carrying them off. We had no numerical check on this dusting because at that time we knew no accurate means of finding the number of crickets per acre.

The dusting was done before sunrise, because the air was then calm and there was dew on the plants. The logical time for dusting for crickets is just before dark, but at that time there is usually a breeze and there is no dew. Dusting by airplane was attempted after sunset on a heavily infested field of 100 acres on July 29, but the wind was too strong and carried the dust up from the cotton plants and in among trees. The same field was dusted on the following morning, however, using calcium arsenate on the north side of the field and a mixture of calcium arsenate 75 per cent with Paris green 25 per cent on the south side, each at the rate of 8 pounds per acre. A second application was made on August 7, from 5.30 to 6 a. m., at which time there was a dead calm, and the dust settled on the plants. The results were as follows:

RESULTS OF AIRPLANE DUSTINGS OF JULY 30 AND AUG. 7. NUMBERS OF CRICKETS PER ACRE

Checks			Experiment			
July 29	Aug. 1		Aug. 5	Aug. 9	Aug. 11	Aug. 13
2,600	832	Calcium arsenate	687	274	753	361
	1,560	Calcium arsenate and Paris Green, 3 : 1	1,394	1,524	853	723

The check count of July 29 was made in the middle of the field that was dusted on the following morning. The check counts of August 1 were made on the north and south sides of the field, respectively.

Thus after the dustings the numbers of crickets decreased on the whole.

Cage tests were made with adult crickets on dusted cotton plants, with 15 crickets in each of two cages, dusted on August 6. In the cage dusted with calcium arsenate the mortality was greatest on the third and fourth days after dusting. In the cage dusted with calcium arsenate and Paris green, 3:1, most crickets died on the fourth day after dusting. All died within eight days, but a check cage showed no mortality. These tests should be repeated, with larger numbers of crickets, especially to determine conclusively which of the two dusts acts the more quickly.

POISONED BRAN MASH. This infestation offered a good opportunity to test poisoned bran mash as a means of control. The formula used was: bran, 50 pounds; Paris green, 2 pounds; molasses, 1 gallon; water,

about 6 gallons. This mixture was broadcast at dusk on 12 successive rows, each 45 feet long and 3 feet 4 inches wide—an area of 1,800 square feet. An adjoining untreated area was used as a check. The counts were made for a distance of 40 feet on three successive rows in the middle of each area; on 400 square feet in other words. The results were as follows:

CONTROL TESTS WITH POISONED BRAN MASH. NUMBER OF CRICKETS PER ACRE

August	22	23	24	25	26	27	28
Poison plat	16,008	7,841	3,920	1,960	1,089	1,416	762
Check plat	2,614	8,059	4,247	4,465	5,118	3,811	2,504

Thus there was a great reduction in the numbers of crickets on the poisoned plat for six days. The number of crickets to begin with on the poisoned plat was remarkably large as compared with that on the check plat. The main reason for this was that crickets flocked to the bran mash from adjacent untreated rows. Furthermore, the odor of the mash may have drawn more crickets from the cracks in the ground. Crickets were often seen feeding on the mash. Now and then a dead cricket was seen on the ground at night, but most of the dead ones were probably carried off by ants during the daytime. Early in the morning there were many dead crickets on the ground.

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FACTORS INFLUENCING INFESTATION IN COTTON BY *HELIOTHIS OBSOLETA* FAB.

By F. L. THOMAS, *Texas Agricultural Experiment Station*, and E. W. DUNNAM, *Entomologist, U. S. Bureau of Entomology*

ABSTRACT

There has been no definite knowledge regarding the factors responsible for the occurrence of an infestation by the cotton bollworm (*Heliothis obsoleta* Fab.). Experimental evidence shows that the proximity of corn to cotton has no relation to the infestation. Egg parasites, although valuable under some conditions, are not as important as the factors which influence egg deposition. Nectar and honeydew are shown to be unimportant. Throughout their growth, the larvae of *Heliothis obsoleta* show a characteristic desire for succulent food and apparently must have it for normal development. The instincts of the moths in selecting succulent plants when ovipositing have a logical foundation in the perpetuation of the species. Odors emanating from rapidly growing succulent cotton appear to be the most important factor influencing infestation in cotton by *Heliothis obsoleta*.

The importance of the cotton bollworm as a pest in Texas has been increasing in recent years. The recommendations of the early investigators for controlling infestations and preventing some of the damage were based on sound principles, but for many reasons these recommendations have not been put into general practice. A decided need developed for further work, and in 1928 the Texas Agricultural Experiment Station and the Bureau of Entomology of the United States Department of Agriculture established cooperative relations for the purpose of conducting studies and making control tests under the changed conditions of the present.

It has long been known that injury to cotton is seldom noticed by growers until it is well advanced. Furthermore, the "spotted" infestations of the cotton bollworm which often occur have caused great uncertainty to arise regarding the probable location, extent, or occurrence of damage by this pest. In fact, there has been no definite knowledge regarding the factors responsible for the occurrence of an infestation by the cotton bollworm. It must be recognized, however, that this knowledge is of extreme importance if control measures are to be applied effectively.

The first question that arose in connection with the determination of the factors influential in bringing about an infestation in cotton was that of the relation of the infestation to the proximity of cornfields.

In our work during the past three years the infestation in corn by *Heliothis obsoleta* has been more or less uniform, regardless of location, although always sufficiently high to produce enough moths to create a severe infestation in cotton; yet this has not always occurred. Annual examinations of cornfields about the first of July have shown that 90 to 98 per cent of the corn ears are usually infested. The injury to cotton by subsequent broods has been very light in some instances and in others extremely severe. Then again, when only 80 per cent of the corn ears were injured, which was less than usual, the injury to cotton following was unusually severe. The method used to determine the relative numbers of eggs present in cotton was an examination at biweekly intervals of the upper surfaces of the leaves and all terminal buds in the upper half of 200 plants. This method was intended to show only comparative abundance of eggs and not the total number present.

The impression that the presence of corn is partly responsible for the later infestation in adjacent cotton has been more or less common, because of the preference of the moths for growing corn. In our experiments to determine this point records were taken in fields of uniform cotton at distances ranging from 5 to 900 yards from corn. It was found

in 1928 that injury to bolls varied less than 2 per cent between distances of 50 and 900 yards, and in 1930 that similar injury varied less than 3 per cent between distances of 5 and 300 yards, which was the farthest point from corn where records were taken. These records were taken under conditions of moderate infestation in cotton, but in another case during 1930, on the 1,200-acre Forrest Plantation, even with severe infestation in cotton practically no difference occurred at various distances from corn. This indicates that the proximity of corn to cotton has very little, if any, relation to the infestation in cotton.

The fact that a severe infestation in cotton does not always develop, following a severe infestation in corn, led us to believe, next, that possibly egg parasites were responsible for the lack of infestation in cotton. In order to determine this point, records were taken of the parasitism in cotton fields and the relation of its abundance to the injury by bollworms. Probably the most convincing evidence was that gained in the Brazos bottoms in 1930. Biweekly records taken throughout the season at 74 points in this area showed that, although no parasitized eggs were found, less than one-tenth of 1 per cent of the bolls were injured by the cotton bollworm. It is obvious that egg parasites were not responsible for the low infestation. Furthermore, indirect evidence indicates that egg parasites or other insects which destroy eggs were not important factors in preventing infestation in the fields under observation. (Table 1.)

TABLE 1. OVIPOSITION IN COTTON BY SECOND-GENERATION MOTHS OF *Heliothis obsoleta* AND RESULTING INJURY TO BOLLS

Year	Location	Plants Examined Number	Eggs Per plant Average Number[1]	Bolls Examined Number	Bolls Injured Per cent
1928	Hutto	1,571	0.1055	6,684	1.90
1928	Taylor	1,647	.012	489	1.39
1928	Granger	950	.0515	4,518	0.95
1928	Brazos Bottoms (College)	1,020	.0205	8,927	1.17
1929	Brazos Bottoms (College)	600	.2015	1,046	32.89
1930	Brazos Bottoms (College)	2,310	.004	15,567	0.02
1930	Brazos Bottoms (Allenfarm, Texas)	600	.1365	5,489	7.72

[1]This was computed from the average number found on 200 plants in biweekly examinations made throughout the season of bollworm oviposition.

Table 1 shows that there has been a close relation during the past three years between the percentage of injured bolls and the number of eggs laid in the cotton. Under certain conditions egg parasites, or egg predators, no doubt, have their influence on bollworm control, but the factors influencing egg deposition possibly have greater importance on the infestation, as shown by the foregoing table.

During the summer of 1930, a large number of individual eggs were tagged and daily records taken. It was found that, even though they hatched, no infestation developed. The failure of young larvae to develop is likewise a very important factor in explaining the lack of infestation.

It would appear that considerable oviposition must take place for a noticeable infestation to develop in cotton. Therefore, a study was made to determine the factors which attract the moths.

Naturally nectar, the more important source of food of the moth, was first considered. The green corn plant, which is most attractive to the moths, is not nectar bearing. The tomato, also an important host plant, is not listed as nectar bearing by either Phillips or Pellett. Alfalfa has been found heavily infested before blooming. Our own examinations of the four sets of nectaries in cotton has shown that there is always present, regardless of topographical location, a sufficient quantity of nectar for food. Incidentally the heaviest bollworm infestations that we have ever observed developed in cotton that had very few squares and blooms. Therefore, the occurrence of a heavy infestation is not dependent on the attractiveness of the secretions of the three sets of nectaries on the squares and blooms. The fourth set of nectaries, which occurs on the leaves, was the only possible source of sweet in this cotton; and since the moths are strongly attracted to plants that do not secrete nectar, it appears as though nectar is not the main factor in the attraction of the moths.

Since it is known that sweet substances are sometimes used as food, attention was next directed to honeydew as an influence in attracting the moths. Records show that honeydew was not present when very heavy bollworm infestations developed in 1929 and 1930. Conversely, in many instances when honeydew was present, bollworm infestations did not develop. Obviously other factors are responsible for the attraction of bollworm moths. These observations answer the question raised by Fletcher (2)[1] in connection with experiments conducted in 1927.

It is a recognized fact that in most cases the female insect selects the larval food by depositing eggs on substances best suited for the nourishment of the larvae. Upon hatching, the young worms usually eat their eggshells and then wander about in search of suitable food. Apparently the larger leaves of corn are not to their liking, for the young larvae do not feed until they reach the tender central roll of leaves or "bud" of corn, the unfolding tassel, the green silk inside the shuck, or the milky

[1]Reference is made by number to Literature Cited, p. 820–821.

kernels of the ear. This "desire" or instinct of the larvae for tender succulent food is also followed when feeding on cotton, tomato, cowpea, alfalfa, bean, and other host plants. This is evidently a characteristic habit of the larvae throughout their growth, and especially just prior to entering the soil for transformation to the pupal stage. Examples of this may be seen when a heavy bollworm infestation occurs on cotton which has been severely injured by flea hoppers, thereby causing a succulent growth, and on young late cotton before bolls have had opportunity to form. In the absence of bolls the larvae, just before reaching maturity, eat into the succulent stems just below the tops of the plants, causing them to break over and giving the plants a "topped" appearance. A remarkable instance of this was observed in the Trinity River bottoms in 1930. Succulent cotton plants which had no bolls were topped to the extent of 2,160 per acre, so great was the "desire" of the worms to obtain succulent food.

A large majority of the newly hatched larvae die while in search of the proper food, and it has been shown by other investigators that when older larvae are forced to feed on dry material, such as kernels of corn, the larvae may remain in the soil for a period much longer than normal, even for the duration of a year, which is very abnormal. It seems, therefore, that plants with succulent growth are attractive to the moths when laying eggs. Such an instinct would have a logical foundation for the perpetuation of the species.

Succulent plants are those which are growing rapidly and already have an abundance of fresh growth. The general impression that rainy weather in July brings about bollworm injury in cotton may readily be explained by the fact that such rains cause an increase in the growth of the plants at a time when the moths are laying eggs. It may be difficult to see any difference in cotton fields at the time the injury is noticed, but, because of richer soil, more abundant moisture, time of planting, or wider spacing, cotton plants may have been growing more rapidly in some fields than in others when oviposition took place, or differences may have appeared in parts of the same field if the soil fertility was uneven or the rainfall irregular. The occurrence of these conditions apparently explains the statement made by Sherman (6) that bollworm damage was heaviest on areas that had been dusted.

It is not uncommon in a dry time for cotton to escape injury by bollworms. This is not because the transforming moths failed to emerge. As a matter of fact, the emergence of bollworm moths may be greater under dry conditions than in wet weather. (Table 2.)

TABLE 2. EMERGENCE OF BOLLWORM MOTHS FROM BLACK LAND SOIL UNDER DIFFERENT CONDITIONS OF MOISTURE, TAYLOR, TEXAS, 1929

Moisture Conditons	Larvae Entering Soil Number	Emergence Period	Per cent
Kept dry	96	June 27 to July 18	72.9
Kept moist	98	June 29 to July 18	58.1
Precipitation 2.09 inches	100	June 26 to July 18	59.0

The lack of infestation in cotton is due to the selective instincts of the strongly flying moths. The occurrence of a period of dry weather has prevented rapid growth, and only a few scattering eggs are laid by the moths, the latter migrating, at least locally, seeking fields with rapidly growing plants and succulent larval food, and concentrating in such places. The preference that *Heliothis obsoleta* has for cotton over tomatoes, as pointed out by Quaintance and Brues (4) was not maintained in the Brazos bottoms in 1930. In cotton fields in which tomato plants were scattered, much larger numbers of eggs were laid on the fairly succulent tomatoes than on the less succulent cotton.

In general the cotton on upland fields is less injured than that on bottom lands. With the overflow of rivers, a supply of rich alluvial soil is left, as well as an abundant supply of moisture, and the cotton on such land is sure to be attractive to bollworms. When general rains occur, the injury is scattered and usually merged with that of the boll weevil, so that it is less conspicuous although probably fully as great as when concentrated or localized.

According to Richardson (5), Scudder and others believe that the oviposition response of some insects is in keeping with the idea that the larval food plant is detected by means of the olfactory sense. McIndoo (3) states that evidently insects have a keener sense of smell than human beings and should be able to distinguish plant odors more readily. Brues (1) in his treatise on the selection of food plants by insects, states that the selection by lepidopterous insects must be considered as dependent upon one or several of a number of factors, such as taste, general form of food plant, and odor.

Since it is recognized that some moths have a keen sense of smell, it may not be too much to presume that bollworm moths are attracted by odors emanating from rapidly growing, succulent cotton. These odors appear to be the most important factor influencing infestation in cotton by *Heliothis obsoleta*.

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CAGE TESTS OF THE EFFECTIVENESS OF INSECTICIDAL DUSTS FOR THE CONTROL OF THE COTTON FLEA HOPPER[1]

By K. P. EWING, *Assistant Entomologist, Division of Cotton Insects, Bureau of Entomology*

ABSTRACT

During the summer of 1930 a new method of conducting toxicity tests for control of the cotton flea hopper (*Psallus seriatus* Reut.) was put into practice which proved entirely satisfactory. Small cages, 18 inches by 18 inches by 24 inches, covered with fine-mesh brass wire cloth and designed to rest on a stool 1 foot high, were used. Approximately 50 insects were placed in each cage for each test. By allowing the host plant to touch the top of the cage the average mortality at the end of four days in the check cages was reduced below 10 per cent.

Seventeen insecticides, combinations of insecticides, or inert materials were tested as dusts for their toxic effects upon the cotton flea hopper. A total of 193 toxicity tests were completed, and there were also 56 cages in which the insects were left untreated as checks. In one hundred and twenty-two of the test cages adults were placed on croton, in forty-nine nymphs were placed on croton, and in twenty-two adults were placed on cotton.

This paper has two primary objects: First, to present a satisfactory method of conducting toxicity tests for control of the cotton flea hopper; second, to give a brief summary of a few preliminary experiments with various insecticides in the control of the cotton flea hopper in which this method was used.

In the past the usual method of conducting toxicity tests for control of cotton flea hoppers was by using small field plats. This method was used by the writer and associates in 1924 and 1925, when sulphur was first experimented with for cotton flea hopper control. The same method was also used by the Texas Experiment Station during the summers of 1925 (3)[2] and 1926 (2).

[1]The routine field examinations reported in this paper were made by Mr. R. L. McGarr. [2]Reference is made by number to Literature Cited, p. 827.

This method is deficient, however, in certain respects, and for several years the writer has been trying to devise a satisfactory method of conducting toxicity tests in cages for cotton flea hopper control. This insect is so delicate that it has always been extremely difficult to handle under artificial or cage conditions.

In 1926 toxicity tests were attempted in which cotton flea hoppers were placed on potted croton plants covered with small cages. In these tests the mortality of the insects in the untreated cages averaged 77 per cent in two days. This high mortality has prevailed practically throughout the years during which we have been introducing flea hoppers into cages for the purpose of studying "hopper" damage, an undertaking in which well over 100,000 individual flea hoppers have been used.

In studies of the behavior of flea hoppers after their release in a cage it was noted that the majority of adults immediately flew to the top. A large number of the nymphs also gradually found their way to the sides and finally to the top of the cage. In the majority of cases only a very small percentage of these individuals ever found their way back to the plant, and this accounted for the high mortality of flea hoppers under cage conditions.

The idea was then conceived that if the plant in the cage was allowed to touch the top, the flea hoppers would come in contact with it and possibly feed and remain on it, and thus the lives of the individuals in the cages would be prolonged. With this in view several experiments were conducted to determine the feasibility of the idea.

The experiments showed that at the end of the first day the mortality in the cages in which the plants touched the top averaged 1.0 per cent, whereas in the cages in which the plants did not touch the top the mortality averaged 50.4 per cent. At the end of four days the mortality in the cages in which the plants touched the top averaged 7.3 per cent, whereas in the cages in which the plants did not touch the top the mortality averaged 65.1 per cent. The plant used in these cages was croton, the preferred host plant of the cotton flea hopper during the summer.

In view of the favorable results obtained in these mortality tests, toxicity tests were begun. The major obstacle encountered in our first tests was the depredations of ants. As the bottom of the cage rested on a canvas cloth spread on the ground around the plant, it was easy for ants to enter the cage. After entering, they not only disturbed the live flea hoppers on the plant but would eat, destroy, or carry off all dead insects, thereby ruining the experiment. Several means of controlling and excluding the ants were tried. All beds of ants that could be located

in the vicinity of the experiments were destroyed with carbon disulphide or kerosene; ant poison was distributed around the cages and tanglefoot was placed on the bottom part of the wooden frame of the cage; but all to no avail. In spite of all precautions to exclude the pests they continued their depredations.

Finally, an "ant-proof" toxicity cage for the hoppers was devised. (Pl. 29.) The cage proper is 18 inches square by 24 inches in height. It is designed to rest on a stool 1 foot in height; thus making the top of the cage 3 feet from the ground, which is approximately the height of croton and cotton plants suitable for toxicity tests. The frame of the cage is constructed of light wood which is covered with fine-mesh brass wire cloth, or screen. For adult flea hoppers 24-mesh screen was used and for nymphs 30-mesh screen. Heavy, 6-ply, glazed, white cardboard was used as a bottom for the cage. The legs of the stool were placed in small pans or cups of kerosene and tanglefoot was placed around the lower stem of the plant. In this way the cage was made ant-proof.

The cost of the cage was approximately $6.20, divided as follows: screen, $1.60; lumber, nails, hinges, felt, and cardboard, $1.60; and labor, $3.

In conducting the toxicity tests approximately 50 insects were used in each cage. The insects were caught in hand nets and immediately transferred to the cages. They were placed in the cages in the late afternoon, and particular care was taken that no injured individuals were used. Before applying the dust on the following day inspections of the cages were made and all dead insects removed. Applications of all the dusts except those containing nicotine were made early in the morning while the dew was still on the plants, usually about sunrise or shortly thereafter. Examinations of these cages were made at 11 a. m. and 5 p. m. the first day and at 8 a. m. and 5 p. m. during the following three days. The nicotine dusts were applied in the heat of the day, or about noon. Examination of these nicotine cages were made at 5 p. m. the first day and at 8 a. m. and 5 p. m. during the following three days. At each examination all dead flea hoppers were removed and their numbers recorded. At the termination of the experiment, or at the end of the fourth day, all live flea hoppers were counted. In this way the exact number of insects utilized in the experiment was determined.

In making the applications, small cylindrical dust guns, approximately 2½ inches in diameter and a foot long, were used. The dust was applied to the plants from outside the cage, or through the screen. In most instances each plant was dusted with what would ordinarily

be called a medium application, or, on an acre basis, approximately 12 pounds. In order to minimize the personal error, all applications were made by the same person. Plate 30 shows a group of toxicity cages set up for tests.

TABLE 1. SUMMARY OF TOXICITY TESTS UPON COTTON FLEA HOPPER ADULTS ON CROTON. TALLULAH, LA., 1930

Insecticide or Dust	Mortality in Treated Cages Per cent	Treated Cages Number	Mortality in Untreated Cages Per cent
4 per cent nicotine, calcium arsenate	84.8	6	10.1
4 per cent nicotine, lime	83.6	6	10.1
Sodium fluosilicate	81.0	17	8.6
Paris green ¼, calcium arsenate ¾ (commercial mixture)	76.7	18	9.1
Paris green ⅓, lime ⅔	59.0	3	13.0
2½ per cent nicotine, calcium arsenate	51.4	6	11.3
2½ per cent nicotine, lime	40.5	6	11.3
Superfine sulphur A	39.5	12	8.6
Superfine sulphur B	38.6	9	8.5
Superfine sulphur C	37.2	6	7.2
Paris green ¼, calcium arsenate ¾ (home mixture)	34.0	6	5.2
Flowers of sulphur	26.0	6	7.2
Barium fluosilicate	25.3	6	10.2
Calcium arsenate	23.0	6	10.9
Paris green ¼, lime ¾	12.3	3	4.5
Talc	7.4	3	4.5
Lime	3.5	3	4.5

TABLE 2. SUMMARY OF TOXICITY TESTS UPON COTTON FLEA HOPPER NYMPHS ON CROTON. TALLULAH, LA., 1930

Insecticide or Dust	Mortality in Treated Cages Per cent	Treated Cages Number	Mortality In Untreated Cages Per cent
Superfine sulphur B	79.9	4	13.6
4 per cent nicotine, calcium arsenate	76.8	3	8.8
Superfine sulphur C	75.8	4	12.1
Superfine sulphur A	75.7	4	13.6
2½ per cent nicotine, calcium arsenate	69.5	3	8.8
2½ per cent nicotine, lime	63.2	2	7.7
4 per cent nicotine, lime	61.0	2	7.7
Flowers of sulphur	60.6	3	13.6
Sodium fluosilicate	60.2	6	10.3
Barium fluosilicate	40.7	4	6.5
Paris green ¼, calcium arsenate ¾ (commercial mixture)	36.4	6	8.1
Paris green ¼, calcium arsenate ¾ (home mixture)	13.6	4	7.3
Calcium arsenate	11.1	4	6.5

A total of 193 successful individual cage tests for toxic effect upon the cotton flea hopper (*Psallus seriatus*) were conducted during the summer of 1930; this being exclusive of 56 untreated cages utilized as checks.

"Ant proof" flea hopper toxicity cage, as set up in field over croton plant.

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Group of flea hopper toxicity cages, as utilized in croton field for tests, Tallulah, La., 1930.

These tests were divided as follows: 122 were conducted with adults on croton,[3] 49 with nymphs on croton, and 22 with adults on cotton. The results of these tests are shown in Tables 1, 2, and 3. The percentages of mortality recorded in these tables are the average total mortalities during the four days of the experiments.

Figure 57 shows the daily accumulative mortality of eleven of the dusts that are recorded in Table 1.

TABLE 3. SUMMARY OF TOXICITY TESTS UPON COTTON FLEA HOPPER ADULTS ON COTTON. TALLULAH, LA., 1930

Insecticide or Dust	Mortality in Treated Cages Per cent	Treated Cages Number	Mortality in Untreated Cages Per cent
Paris green ¼, calcium arsenate ¾ (commercial mixture)	96.3	8	17.2
Sodium fluosilicate	93.3	9	17.2
Superfine sulphur	49.7	5	17.0

The insecticides used were secured from reputable manufacturers and were materials of standard quality. All nicotine mixtures were home-mixed, according to the method recommended by the U. S. Department of Agriculture, in Leaflet No. 53 (1). The three grades of superfine sulphur designated as A, B, and C differed principally in their respective physical qualities. The manufacturers of these sulphurs claim the following physical properties for them:

Superfine Sulphur A:
Fineness: 95 per cent passes 300-mesh screen or 99 per cent passes 200-mesh screen.
Volume: 40 cubic inches per pound.
Purity: 99.8 per cent pure.
Superfine Sulphur B:
Fineness: 99 per cent passes 300-mesh screen.
Volume: 36 cubic inches per pound.
Purity: 99.5 per cent pure.
Superfine Sulphur C:
Fineness: 99 per cent passes 300-mesh screen.
Volume: 40 cubic inches per pound.
Purity: 98.5 per cent pure.

Talc and lime were used in several cage experiments to determine whether a pure inert dust had any effect on the mortality of the cotton flea hopper. These tests showed positively that neither of them is toxic to this insect.

Briefly summarizing the results of the cage tests, we may say:

The 4 per cent nicotine dusts proved very effective in killing both adults and nymphs, while the 2½ per cent nicotine dusts were considerably less effective.

[3] *Croton engelmannii* Ferguson.

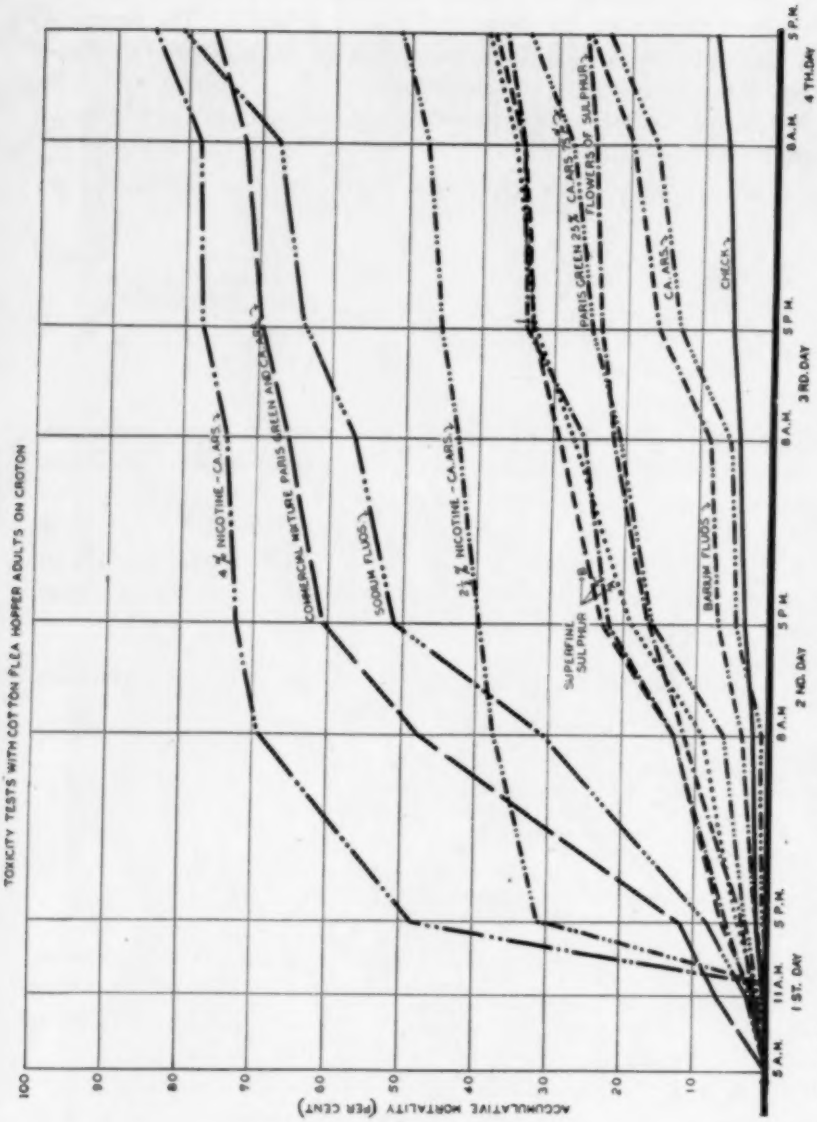

FIG. 57.—Summary of cage toxicity tests with *Psallus seriatus* adults on *Croton engelmannii;* showing daily mortality after use of various insecticides as compared with mortality of check. Tallulah, La., 1930.

Sulphur was very much more toxic to nymphs than to adults. Each of the three grades of superfine sulphur was more toxic than the flowers of sulphur.

A most striking result was the high kill secured by both sodium fluosilicate and the commercial mixture of calcium arsenate and Paris green. Exactly why and how these insecticides produce their kill are questions for additional research. Furthermore, these results will have to be verified by further tests and the materials tried under open field conditions before conclusive proof of their value as controls for the cotton flea hopper can be ascertained. It is especially interesting to note that the results with the commercial mixture did not check with those secured from a homemade mixture of the same proportions.

Neither barium fluosilicate, nor pure calcium arsenate, nor any of the home-mixed Paris green combinations showed any promise as practical insecticides for cotton flea hopper control.

It should be remembered that these experiments are of a purely preliminary nature, and that the results are not offered as final.

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A CHEMOTROPOMETER

By J. W. FOLSOM, *Senior Entomologist, Bureau of Entomology*

ABSTRACT

A simple form of chemotropic apparatus and its method of operation are described. Records of chemotropic reactions of the Mexican boll weevil, obtained with this apparatus, are given.

DESCRIPTION OF APPARATUS. For testing the chemotropic reactions of the boll weevil (*Anthonomus grandis* Boh.) the writer made, in 1925, an apparatus that gave excellent results. This apparatus, or *chemotropometer*,[1] is so simple that the possibility of errors arising from the construction of the apparatus itself is minimized. In principle the apparatus is essentially a glass tube,[2] one inch in outside diam-

[1]Name approved by Prof. W. M. Wheeler.

[2]Others, as Prof. Jacques Loeb and Mr. D. C. Parman, have used glass tubes for similar purposes.

eter, in which weevils are confined with the reagent to be tested. For practical purposes the tube is in four sections: a *reagent tube* (four inches long), a *reaction tube* (nine and one-half inches) and two *air tubes* (each three feet long). These tubes are arranged end to end, as in Figure 58.

If a fluid reagent is to be tested, a piece of absorbent cotton is moistened with the fluid and placed in the reagent tube. Bulky substances, such as cotton leaves, squares, flowers or bolls, are placed in a lamp chimney, which is substituted for the reagent tube.

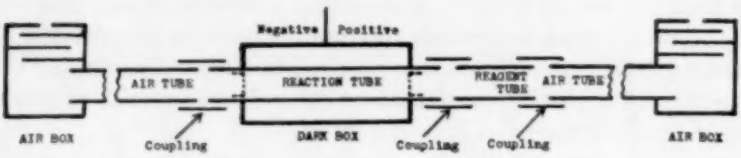


Fig. 58.—Diagram of chemotropometer.

Boll weevils, whose responses to stimuli are to be tested, are put into the reaction tube, each end of which is plugged with a thimble made of screen wire. In the reaction tube the weevils are free to move either toward or away from the source of stimulus. The reaction tube is divided across the middle, by a narrow strip of adhesive plaster, into two equal regions—positive and negative, respectively.

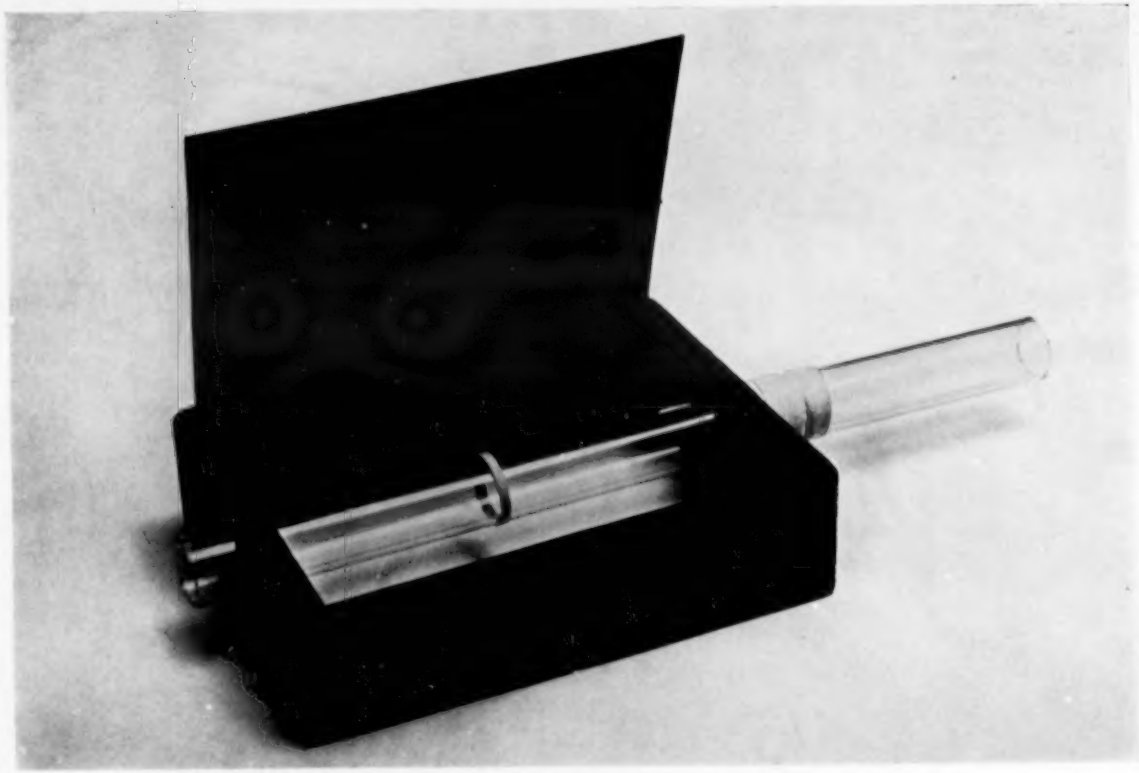
The air tubes are simple straight tubes, one of which is coupled to the reagent tube, and the other to the reaction tube. The outer end of each air tube enters a dark box which has an air hole on one side (Fig. 58). Light that enters the air hole is prevented from reaching the air tube by a set of alternating partitions, or baffles, as in the figure.

With boll weevils in the reaction tube and a source of stimulus in the reagent tube, the four tubes are coupled together with wrappings of paper and adhesive plaster.

PRECAUTIONS. In chemotropic experiments with the boll weevil its strong positive phototropism is a disturbing factor that has to be reckoned with. This factor was eliminated by conducting the chemotropic tests in darkness. To this end, the glass tubes, except the reaction tube, were wrapped with opaque paper; all joints were wrapped with black cloth; and the entire apparatus when in use was covered with black cloths. The reaction tube was made to pass through an *observation box* (Plate 31) about 7 in. long, 5 in. wide and 2½ in. high. The

Observation box containing reaction tube, to which is coupled the reagent tube.

Plate 31



Observation box containing reaction tube, to which is coupled the reagent tube.

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box has a cover, which is removable to permit observation of the weevils within the reaction tube.

With the aid of a spirit level, the reaction tube was made horizontal.

The temperature of the air surrounding the apparatus was uniform. The temperature within the reaction tube was taken at each chemotropic test, and proved to be almost invariably one degree F. higher than that of the air outside the tube.

At first a small electric fan was used to draw a current of air through the tubes, carrying the odor of the reagent into the reaction tube. It was soon found, however, that in the absence of a reagent the weevils reacted positively to the air current itself, even when the current was almost imperceptible. The use of the fan was discontinued, therefore, and it was found that the simple diffusion of air through the tubes gave a gradient of intensity that proved to be sufficient to cause chemotropic responses.

Most of the reagents used as stimuli were in solution in distilled water. When distilled water alone was tested, weevils reacted positively to it. As there was no way of eliminating this positive reaction, its average intensity was determined by means of many tests and allowance made for it in the interpretation of results.

Chemically clean tubes were used for each test. After use the tubes were cleaned with dilute hydrochloric acid, washed with distilled water, and dried.

For chemotropic tests only fresh, active weevils were used. They were collected every day and kept alive in screened jars containing cotton leaves and squares. New weevils were used for each test, except of course when the object of the test itself required a second exposure.

The weevils were not touched with the fingers, and seldom with any instrument. Advantage was taken of their positive phototropism by allowing them to walk or fly from their darkened container into an illuminated reaction tube.

OPERATIONS. The number of weevils used for each test was usually twenty-four. After they were put into the reaction tube, the ends of the tube were shielded from sunlight, causing the weevils to concentrate in the middle of the tube. The observation box was then closed, and the weevils left in total darkness for twenty minutes. Then the distribution of the weevils in the reaction tube was observed with the aid of a small flashlight, under the protection of a focusing cloth.

In the absence of any stimulus, weevils should theoretically distribute themselves uniformly in the reaction tube. This they actually did. Not infrequently the distribution was: 12 positive, 12 negative. Usual-

ly, though, the distribution was not exactly 12:12, but closely approximated that ratio. This check test on the apparatus itself was made constantly, and every test with a reagent was preceded and followed by a test of the apparatus. If a check test showed any preponderance (15 or more) of weevils at either end of the reaction tube, the apparatus was overhauled, and usually the cause of the disturbance was found to be a light-leak. Such leaks were liable to occur unless the tubes were coupled and wrapped with the greatest care to exclude light.

With apparatus and methods apparently perfected, there still remained to be reckoned with the most complex and variable factor of all, namely, the physiological condition of the weevils themselves. They displayed extremes of individuality in their responses to stimuli. Never did 100 per cent of the weevils react alike, except toward light. Some of their differences in behavior toward stimuli are explicable. For example, weevils that have been deprived of water for 24 hours are more strongly positive toward water than weevils that have been supplied with water. Fed and unfed weevils likewise react differently to the same stimulus. Weevils after exposure to strong concentrations of a chemical become less sensitive to weaker concentrations. Other possibilities can be imagined. As an example, individuals may differ in the sensitiveness of their sensory mechanisms. Their vitality may have been reduced by age, disease, mechanical injury, starvation, or other adverse influences. Differences correlated with sex may account for certain differences in behavior. Most of these factors are within the possibility of experimental control; though as yet we have simply taken the weevils as they came, provided they were well fed and active.

RESULTS. The most important and most interesting of our many records of chemotropic reactions of the Mexican boll weevil are here presented. The results are expressed in terms of percentages of the total number of individuals used in each test, and the percentages given here are average percentages, based upon from three to as many as eighty-nine tests.

REPELLENTS. The negative reactions to different repellents vary in degree according to the kind of repellent used. For example:

	Positive	Negative	No. of Tests
Acetic acid, 10 per cent	35.7	64.2	4
Carbolic acid	34.9	64.9	1
Turpentine	26.6	73.3	1

ATTRACTANTS. PARTS OF THE COTTON PLANT:

	Positive	Negative	No. of Tests
Leaves	58.6	41.3	6
Flowers	60.8	39.0	17
Squares	65.6	33.5	12
Bolls	51.7	48.2	16

COTTON DEW. The reaction to cotton dew is interesting in comparison with that to distilled water.

	Positive	Negative	No. of Tests
Cotton dew	76.9	23.0	5
Distilled water	64.7	35.2	89

Thus the former positive reaction is 12 per cent stronger than the latter. Cotton dew contains 74.42 parts (by volume) of ammonium hydroxide and 3.58 parts of trimethylamine in 1,000,000 of water (Bureau of Chemistry, Power and Chesnut, Jour. Amer. Chem. Soc., 47: 1751–1774).

COTTON VARIETIES. As would be expected, the weevils reacted differently to different varieties of cotton. The following records are of reactions to fresh leaves of four varieties that were being grown at Tallulah, La.

	Positive	Negative	No. of Tests
Wannamaker Big Boll	61.0	39.0	5
Mexican Tree Cotton	60.0	40.0	3
Sea Island Cotton	68.1	31.9	3
Pima Cotton	75.0	25.0	3

These records confirm the statements by Hunter and Pierce that Sea Island cotton is more susceptible to weevil attack than American upland cotton, and Egyptian cotton still more so.

Seven years ago the Bureau of Chemistry, in cooperation with the Bureau of Entomology, analyzed the distillate from cotton plants for the purpose of determining its principal volatile constituents. These proved to be ammonia and trimethylamine which, it was assumed, might be attractants of the boll weevil—as they have since proved to be.

TRIMETHYLAMINE. The average reactions of the weevils to 1 volume of trimethylamine in 1,000,000 of distilled water were: positive, 66.6 per cent; negative, 33.3 per cent. Strong trimethylamine is, however, a repellent, and the concentrated solution of 33 per cent of the gas in distilled water stupefies the weevils. Following are the records from one series of consecutive tests, showing the gradual change of trimethylamine from an attractant to a repellent, accompanying successive increases in the strength of the solution.

Exp. No.	Concentration	Positive	Negative	No. of Tests
116	1 : 1,000,000	64.5	35.4	1
117	500,000	56.2	43.7	1
118	200,000	58.3	41.6	1
119	100,000	43.7	56.2	1
120	10,000	31.2	68.7	1

The record for Exp. No. 117 is inconsistent, but in seven other tests with the same concentration the results averaged: positive, 60.4; negative, 39.5, and these would fit nicely into the series.

Ammonium Hydroxide. This is even superior to trimethylamine as an attractant of the boll weevil, and is likewise in strong concentrations a repellent. One series of successive tests with successively stronger concentrations gave these results:

Exp. No.	Concentration	Positive	Negative	No. of Tests
101	1 : 1,000,000	77.0	22.9	1
102	500,000	58.3	41.6	1
103	200,000	54.1	45.8	1
104	100,000	45.8	54.1	1
105	10,000	31.2	68.7	1
106	1,000	18.7	81.2	1

Miscellaneous. To geraniol, a powerful attractant of the Japanese beetle, the Mexican boll weevil reacted with: positive, 63.1 per cent; negative, 36.8. Amyl salicylate (5 per cent) used with success by Morgan to attract tobacco moths, gave: positive, 57.6; negative, 42.3 Louisiana molasses, negative, 53.3; positive, 46.6 Equal volumes of rain water and of a saturated solution of granulated sugar gave: positive, 55; negative, 45. It was interesting to find that the Mexican boll weevil reacted positively to calcium arsenate. Reactions to dry calcium arsenate were: positive, 59.5; negative, 40.4; and to wet calcium arsenate: positive, 63.5; negative, 36.4.

Field Exposures. The main purpose of these chemotropic tests was, of course, to find an attractant that could be used as a bait to lure the boll weevil to its destruction; if possible, some substance that should be superior to the cotton plant as an attractant.

The reagents used in our field exposures were synthetic cotton dew, and various concentrations of trimethylamine and of ammonium hydroxide. Optimum concentrations could not be calculated but had to be arrived at empirically. Exposures were made by many different methods, but the best results attended the use of our standard migration screens for chemotropic purposes. Each screen had two wings of screen wire, at right angles to each other and coated with tanglefoot. Such a screen was used as a check, in a cotton field, and not far from it a second

screen was installed, covered with tanglefoot plus an attractant. Twelve pairs of these screens were set up in cotton fields in the vicinity of Tallulah, La., and visited daily.

The results of our field exposures were inconclusive until July, 1929, when the check screens caught 65 weevils during the month, and the screens treated with 1 volume of ammonium hydroxide to 50 of distilled water caught 167 weevils. In August, 1929, the check screens caught 440, and the screens coated with 1 volume of trimethylamine to 100 of distilled water caught 1,003. These results were promising. In the hot dry season of 1930 very few weevils were caught on the screens.

Most of our routine chemotropic work was carried on by R. Melvin, E. W. Dunnam, M. T. Young, and G. L. Smith.

A NEW ECONOMIC SPECIES ATTACKING SOYBEAN HAY IN LOUISIANA (*HERCULIA PSAMMIOXANTHA* DYAR)

By W. E. Hinds, *Entomologist, Louisiana Experiment Station*

Abstract

This species has occurred during several years past in the southern part of Louisiana where it has been found attacking soybean hay after it is cured. This being the first known record of economic importance for this species, the information is placed on record.

For several years past there have been rumors of some caterpillar doing damage to cured soybean hay in the southern part of Louisiana but it was not until the fall of 1929 and again in 1930 that specimens were sent to the Experiment Station at Baton Rouge and the seriousness of this attack investigated.

The center of this most common occurrence of this species appears to be in Iberia Parish which by an interesting coincidence is also the center for heaviest attack of the soybean caterpillar (*Anticarsia gemmatilis*). The area affected appears to extend for perhaps 35 miles radius from this center. Specimens of the worms and injured hay were sent to the Experiment Station the middle of October 1930, and the identity of the species was kindly determined for us by Mr. Carl Heinrich of the U. S. Bureau of Entomology. This confirms the identification which we received also from Mr. W. A. Douglas of the Bureau of Entomology and other parties. So far as Mr. Heinrich could ascertain there is no record of this species as being of economic importance. A number of species of the genus *Herculia* are recorded from the United States,

but so far as I have been able to find none of these seems to be of economic importance.

The original description of *Herculia psammioxantha* Dyar is taken from "Seven New Pyralids From British Guiana" by Harrison G. Dyar—Insecutor Inscitiae Menstruus—Vol. 5, 1917, page 90 and is as follows:

"Brownish straw-color, densely dusted with fine brown scales; lines straight, parallel, erect; a faint discal dot, often absent; outer line faintly edged with pale.

Hind wing with two dark lines, approximating toward inner margin, faintly pale edged, the inner toward base, the outer outwardly; outer line originating not far from middle of costa, reaching inner margin at its outer fourth. Expanse 16 mm.

Type, male, No. 21132, U. S. Nat. Mus.; Plantation Vryheid's Lust, Georgetown, British Guiana, August, 1915 (H. W. B. Moore), bred from larvae on withered, fallen leaves of trumpet tree. Other specimens are before me from Cayenne, French Guiana, January, 1904 (W. Schaus).

Santiago and Matanzas, Cuba, June and August 1902 (W. Schaus).

The female is larger, expanse, 17–20 mm."

It would appear that this species has other food plants besides soybeans and that it has been introduced into the gulf coast region, probably from Cuba.

So far as we know at the present time it attacks soybean hay after it is harvested and cured and the damage reported has been to hay in the stack in the field and in barns where the hay has been stored. Where the hay has been baled, the damage, of course, has been confined to the exterior of the bale but even here it results in a decidedly dirty, ragged appearance which would depreciate the value of the baled hay to a considerable extent. In loose hay in stacks and in barns the damage appeared to be confined, as a rule, to the exterior of the stacks, but the amount of penetration into the mass would probably depend in quite large degree upon the hardness of stalks of the soybeans and the looseness of the mass.

From personal interviews and from correspondents we have developed the following general information. The species has been noticed by a few individuals at times during the past eight or ten years but at no time before 1929 was the damage considered to be severe. In that year, however, in the vicinity of Jeanerette, Louisiana, some hay placed in stacks in the field was so heavily infested that the leaf tissue was practically totally destroyed, leaving but a mass of sticks or

Herculia psammioxantha—Stages and Work

1 and 2.—Adults, larva, pupa and pupal cases, X 3/2.
3.—Appearance of infested soybean hay, X 3/4. Original.

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hard stems. In loose hay in barns the damage has also been severe at times. In more compact bodies the damage is restricted rather largely to the exterior and surface area. In some cases the farmers have become sufficiently alarmed by the damage done in the barns so that they have removed the hay and baled it to prevent further loss. It appears quite probable that baling may prove to be a fairly effective method of preventing serious injury.

The indication that the species is of tropical origin appears to be confirmed by the fact that the larvae disappear immediately after the first heavy frost or cold weather of the fall in Louisiana. Whether the species hibernates in this territory is not certain, but it appears likely that some specimens do survive. The winter of 1929 to 1930 was unusually severe in Louisiana and yet the infestation of 1930 appeared to have been about as heavy as it was in 1929. Search for the species at Baton Rouge has failed to reveal specimens in this locality.

Inasmuch as this new economic species has been found only on soybean hay, it would seem that the common name "soybean hay caterpillar" might well be considered for this species. Illustrations of the insect and its work appear in the accompanying figures.

ECONOMIC IMPORTANCE OF THE SALT-MARSH CATERPILLAR (*ESTIGMENE ACRAEA* DRURY) IN LOUISIANA

By C. L. STRACENER, *Assistant in Entomology, Louisiana Experiment Station*

ABSTRACT

This paper is a discussion of the economic importance of the salt-marsh caterpillar with special reference to Louisiana, giving a brief summary of life history and control measures used.

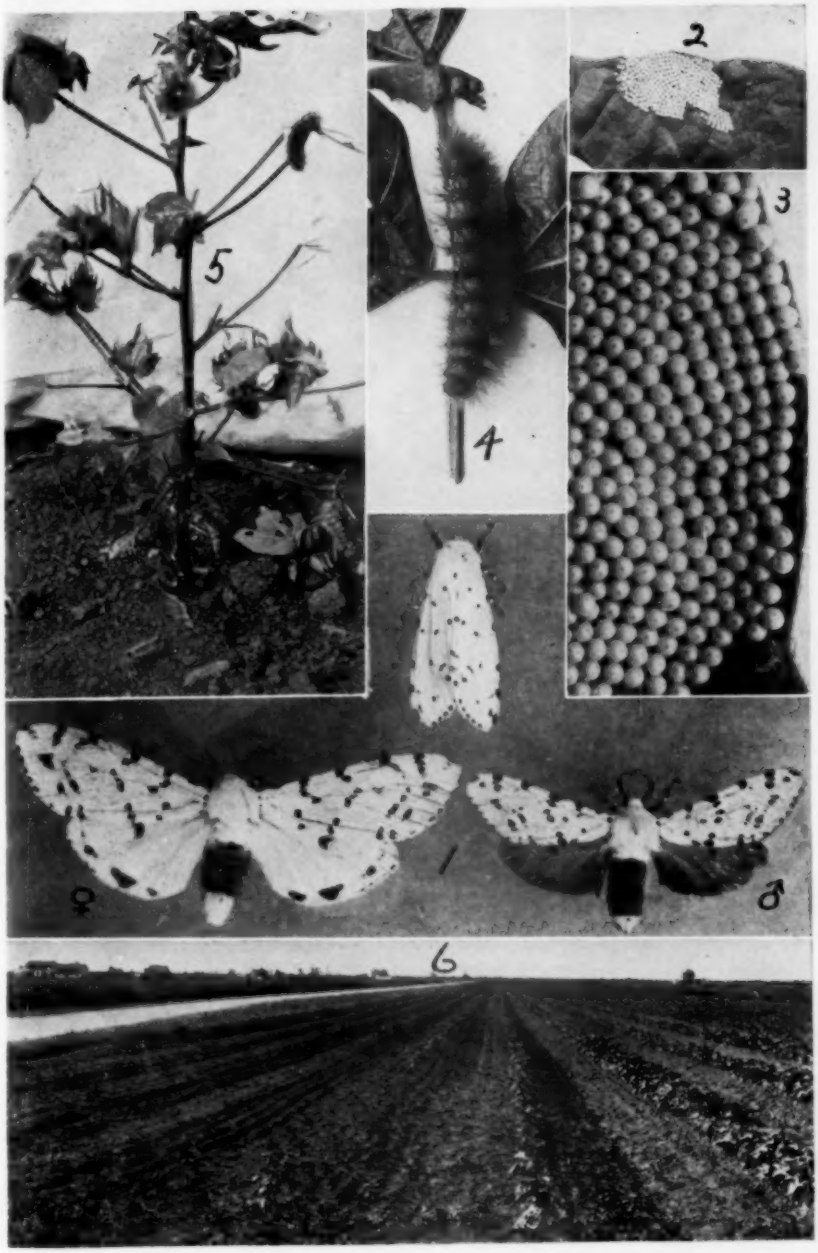
A study of the salt-marsh caterpillar (*Estigmene acraea* Drury) to determine some of the parasites which prey upon it in this region revealed the fact that but little investigation has been recorded in the south or in Louisiana in particular. This species was described in Europe by Drury in 1770 and has been mentioned briefly by numerous writers in this country. It is of wide-spread distribution and occasionally of considerable economic importance. It seems strange, therefore, that it has not received more notice. Occasional outbreaks, which are always more or less local in scope, have brought it to the attention of the economic entomologists. The fact that the south is adopting the more improved methods of agriculture and is now growing legumes in large areas in regular rotation makes a more complete consideration of

this insect worthwhile. While the greatest damage done to crops in Louisiana has been to cotton and soybeans (*Glycine hispida*), the larger larvae will feed on almost any green plant when their preferred food becomes scarce.

Host Plants. It has been generally believed that the salt-marsh caterpillar feeds almost entirely on weeds. It is true that infestations start in pastures or weedy areas where the larvae feed on various grasses and wild legumes. Some weeds are plainly preferred hosts, especially spiny pigweed (*Amaranthus spinosus*), and another *Amaranthus* sp., wild coffee (*Cassia tora*), and the so-called "Yankee weed" (*Eupatorium capillifolium*) etc., and are common food plants. However even these weeds will be passed by when surrounded by legumes, or cotton plants. Under necessity the larvae will feed on almost any green plant but they seem to prefer the legumes. They will feed on the wild clover (*Trifolium repens*) when surrounded by weeds, but will often crawl up on high weeds where they are thought to be feeding by a casual observer.

There was also much complaint in the summer of 1930 about this caterpillar destroying garden flowers, the most severe damage being done to dahlias. The greatest damage done to field crops has been to cotton and soybeans. The damage done to cotton in the spring and summer of 1930 was severe especially in the lower part of the Parish of Lafourche, which is known as the "lower Lafourche" country. This area is flat and at about sea level. Here one planter reports 20% damage done to cotton and estimates that his crop was 250 bales short from that source alone. It was no uncommon sight, he states, to see whole fields of cotton destroyed by these caterpillars, where the infestation was heaviest leaving only the bare stalks and stems in the fields. Other plantations in this locality were similarly attacked. This damage was due to migrating caterpillars mainly. Dr. W. E. Hinds, while investigating cotton conditions, visited this district on June 12 and made some photographs, two of which are given herewith. (Pl. 33, Figs. 5 & 6). He reports serious damage in many places from the caterpillar. The most heavily infested area was within about sixty miles of the coast but heavy infestations occurred along the Mississippi River bottom lands as far north as Baton Rouge.

The author made collections of larvae along Bayou Lafourche at Houma, Raceland, Thibodaux and Donaldsonville. Here the planters give their principal attention to sugarcane. In fact, only sugarcane plantations were visited. The caterpillars were found on soybeans quite commonly and in two or three plantations damage of note was reported. In a field at Donaldsonville visited when the beans should have



Estigmene acraea.—Stages and Work

1.—Adults; 2 and 3.—Eggs; 4.—Full-grown larva; 5.—Cotton being defoliated in spite of poison; 6.—Cotton field showing first 5 or 6 rows next to roadway almost completely destroyed. All original; 1, 2 and 4 reduced 4/5; 3 —Enlarged 4/1.

been about knee-high, the stand of beans had been entirely destroyed. In this field corn planted with the beans was attacked after the beans were destroyed. As a rule, the caterpillars attack corn only when forced to do so.

It has been known for years that the salt-marsh caterpillar is destructive to cotton at times. Hinds[1] reports an outbreak of this caterpillar in south Texas in 1902, where considerable damage was done. Morrill[2] reports damage done to cotton, beans and other truck crops in Arizona in 1918.

Truck crops and tobacco are also used as food plants by the salt-marsh caterpillar. The United States Department of Agriculture yearbook for 1907 points out this insect as attacking truck and garden crops, and flowers in the eastern states and elsewhere. Forbes and Hart[3] report damage to beets and other vegetables in 1900. Hooker[4] reports injury to tobacco in 1905, one field being almost destroyed in May of that year. He mentions hand-picking as the most effective control used. Arsenicals were also used.

CONTROL MEASURES. Control of the salt-marsh caterpillar in the early stages by poisoning is made difficult by the fact that the larvae of the first three stages feed mainly on the under surface of the leaves. After this they begin to feed rather from the edge of the leaf, leaving only the larger veins and mid-rib of the leaf. During this stage they may be poisoned easily. Arsenicals have long been used in their control, probably calcium arsenate having been most commonly used. Sodium fluosilicate was used with best results in the outbreak in the Lafourche district last summer. A number of planters used sodium fluosilicate on the recommendation of Dr. Hinds and excellent results were reported.

The use of sodium fluosilicate for control of the salt-marsh caterpillar has shown that it possesses considerable advantage over arsenicals for this purpose. In the initial work of 1930 applications were made to cotton along several rows on the edge of the field in an effort to protect the main body of the field from the attack of hordes of migrating worms. In this effort three heavy applications of sodium fluosilicate were made within a period of eight days and while the dew was on the plants in order to make as much poison as possible adhere to the reduced amount of foliage remaining. Even this severe treatment did not cause any burning of the cotton foliage. In this work care was taken that no

[1]Hinds, W. E. U. S. Bur. Ent. Bul. 44, pp. 80–84. 1904.
[2]Morrill, A. W. Arizona Exp. Sta., Bul. 87, p. 183. 1918.
[3]Forbes, S. A. and Hart, C. O. Ill. Agr. Exp. Sta., Bul. 60, pp. 504–506. 1900.
[4]Hooker, W. A. U. S. Bul. 67, p. 109. 1907.

arsenical had been used in the dust guns, or became mixed with the fluosilicate. Any mixture of calcium arsenate with sodium fluosilicate results in the liberation of free arsenic which would cause defoliation of cotton or any other crop.

BRIEF OUTLINE OF LIFE HISTORY. The moths of the salt-marsh caterpillar have a wing spread of from one and three-fourths to two and one-half inches among the females and somewhat less among the males. The moths fly slowly and for only short distances at one flight. When at rest the wings are folded over the abdomen and show only the speckled white of the forewings. When the wings are spread, the dorsal surface of the abdomen of the female is shown to be bright orange in color with white at both base and tip and with a row of conspicuous black dots along the back. In the male the underside of the forewings, both sides of the hindwings and the abdominal band are orange in color. Mating occurs during the night following emergence and egg deposition begins usually during the second night. Females live four or five days after oviposition begins and may deposit more than one batch of eggs. The males live only three or four days after mating and appear to mate only once. Eggs hatch in four days usually. The color of larvae varies greatly, ranging from a creamy white to a dark brown. When grown, the larvae reach a length of from one and one-half to two inches. There are usually six molts before pupation and about six weeks is required to complete the life cycle. There appear to be three generations in Louisiana. The second generation is usually the one which does most severe damage to crops and the period of injury occurs principally between May 20 and July 1.

The distribution of larvae seems to occur in two principal ways. First, the young larvae feeding upon a plant will drop readily when the plant is disturbed and hang suspended by a thread of silk. While thus hanging, these larvae may be blown to considerable distances by winds and thus disperse to other plants. Second, after they become half-grown the larvae do not spin down so readily but crawl rapidly over the vegetation, ground and roadways and may evidently go to a considerable distance in their search for food.

METHODS IN REARING DIABROTICA

By J. M. ROBINSON, *Entomologist* and F. S. ARANT, *Assistant Entomologist, Alabama Agricultural Experiment Station*

ABSTRACT

A rearing method for the developmental stages of different species of Diabrotica consisted of the use of sprouting corn in glass vials that were 60 mm. high and 30 mm. in diameter. Moisture was retained around the sprouting corn by the use of moistened cotton. This method provided adequate conditions for a quick and accurate observation of the various stages, with a minimum disturbance to the developing insect.

In studying the life history of *Diabrotica 12-punctata* Fab. and *Diabrotica balteata* Lec. it became necessary to establish a method whereby the developing larvae might be quickly and easily observed. Since considerable difficulties were encountered by previous investigators in rearing root-feeding larvae, this report on methods of life history studies is published. A very brief account of the rearing method for *D. 12-punctata* was published in 1929 (1).

REVIEW OF THE LITERATURE. The first published record of a Diabrotica life-history study was by Garman (2) in 1891. His work was with *D. 12-punctata*, but he cited no actual rearing records. Quaintance's work with the same insect followed in 1900 (6). While rearing records were mentioned, practically nothing was published on actual methods of rearing.

Marsh (5) in 1912 reported rearing methods for the three species now occurring in Alabama, namely *12-punctata*, *balteata*, and *vittata*. Jelly glasses were used for larval cages and the larvae were fed sections of sorghum cane. All species were reported as difficult to rear, with *12-punctata* most difficult and *balteata* least.

In 1925, Sweetman (8) reported rearing records for *D. vittata* and in 1926 (9) for *D. 12-punctata*. The latter report was the first published record of methods for rearing all stages. While little information was given on rearing methods for *vittata*, the methods used for *12-punctata* are presumably applicable to both. Adults collected from the field were caged in 72 x 24 mm. shell vials, covered with nainsook cloth, and supplied with cucurbit leaves for food. Eggs were removed daily and placed in moist soil. Upon hatching, each larva was placed upon a small piece of cucurbit stem in a vial containing moist soil. Pupation occurred in the soil.

Isely, in 1927, reported methods for *vittata* (3), and in 1929 for *12-punctata* (4). These two methods were essentially the same. Adults

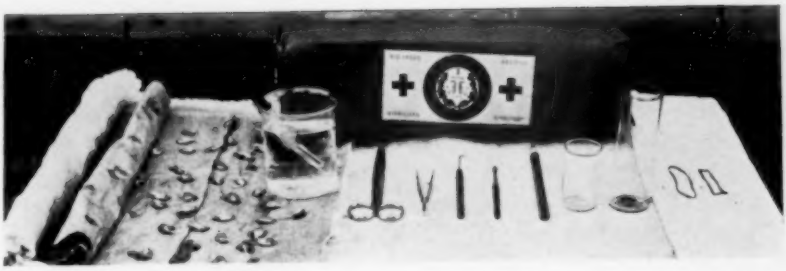
were caged in glass battery jars covered with muslin, or in fourth-ounce screw-capped vials. Moist soil in tin lids was placed on the bottoms of the cages for oviposition. This earth was removed daily. Eggs, larvae, and pupae were reared in salve boxes about half filled with moist soil. Flowers and leaves of cucurbits and cowpeas were used largely as food for adults. *Vittata* larvae were fed large roots or underground stems of cucurbits. *Twelve-punctata* larvae were fed various foods with rather unsatisfactory results until the use of freshly-sprouted corn was finally adopted.

Searls (7) in 1927 published a method for rearing root-feeding arthropods, including one of the Diabroticas. Adults were confined in screen wire cages and allowed to deposit eggs on moist blotting paper. Eggs were incubated in cells made of glass tubing, with one end stopped with plaster of Paris. Larvae were reared in petri dishes containing a layer of plaster of Paris in the bottom. A seedling of the host plant was placed in each dish with the root spread out over the plaster of Paris. A piece of blotting paper, saturated with a nutrient solution for the plant, was then placed in the dish before it was covered with a glass plate. The larvae fed upon the roots of the seedlings and could be readily observed. When the prepupal stage was reached, the developing insects were transferred to special pupation cages and furnished with moist soil.

Method of Rearing. In establishing a rearing method for the immature stages of Diabroticas it was desirable to facilitate the arrangement of vials for ease and speed in making the necessary observations. It was also desirable to conserve space. The methods for the two species of Diabroticas were essentially the same and they were improvements over the previous methods cited.

Manipulation of Adults. Adults, collected from the field or reared in the laboratory, were confined in glass vials 114 mm. high and 40 mm. in diameter (Plate 34, A). A circular piece of moist blotting paper for oviposition was placed in the bottom of each vial and a cotton plug, wrapped in clean cheese cloth, was placed in the mouth. Bean leaves were primarily used for food, although leaves of cucurbits, tomatoes, and a few other plants were occasionally used. The stems of the leaves were wrapped in moist absorbent cotton to keep the food fresh. Observations were made daily, eggs were removed and counted if present, and fresh food was added when necessary. Adults were transferred to clean vials when those in use became soiled.

Egg Incubation. Eggs were placed on moist cotton in vials 60 mm. high and 30 mm. in diameter for incubation (Plate 34, C). A dis-



Equipment used in rearing Diabrotica.

(A) (B) (C) (D)

Vials used in rearing larvae of Diabrotica. (A) For adult, (B) Young sproutlet ready for larva. (C) Eggs on cotton for incubation, (D) Soil added for pupation.

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secting needle, bent near the point to form a right-angled hook, was found to be a satisfactory instrument for transferring eggs. After the eggs were transferred, it was necessary to add a little clean water to the absorbent cotton each day to maintain the moisture necessary for incubation.

LARVAE AND PUPAE REARING. Larvae and pupae were reared in vials of the same dimensions as the incubation vials. Upon hatching, a young larva was placed upon sprouted corn. The grain of corn rested upon the bottom of the rearing vial and the absorbent cotton, used to maintain the moisture necessary for development, was placed upon it in such a way that the sprout grew up between the side of the glass container and the cotton (Plate 34, B). Roots were produced beneath the cotton, and the larva feeding upon them could be readily observed. A grain of corn bearing a sprout not over one inch long was found to be best for a very young larva, while a slightly larger sprout was more satisfactory for an older one. When it became necessary to change the food, the larva was transferred by means of a small soft camel's hair brush, and the cotton was pressed down upon the sprouted corn before the larva was placed upon it. Soil was added to the vial when the prepupal stage was reached. Pupation occurred in the soil which was kept moist until the adult emerged (Plate 34, D).

DIFFICULTIES ENCOUNTERED. Several minor difficulties were encountered. The larvae sometimes drilled into the stems of the plants and could not be observed. This occurred most frequently when the corn sprouts used were too large. Some difficulties were also encountered in preventing the growth of fungi. This problem was never very serious as strict adherence to a few simple practices of cleanliness and aeration solved it satisfactorily. These are discussed in the following paragraph.

The rearing vials were thoroughly washed before using and placed in covered pasteboard boxes stored in a wooden cabinet. The absorbent cotton used was high grade sterilized material and the blotting paper was clean machine-made disks. Tap water was used to furnish moisture. The cotton plugs in the vials for adults permitted a certain amount of air circulation, yet prevented the passage of fungous spores into the vials. The incubation and rearing vials were left open, to allow free circulation of air, until after pupation had occurred. A piece of cheese cloth was then placed over the top and held in position by a rubber band. Cheese cloth could not be used permanently for covering vials as the older adults gnawed through it and escaped. This method of rearing proved very satisfactory as it permitted accurate observations, required little space, induced a low mortality, and demanded few changes of food and consequently little transferring of larvae.

UNSATISFACTORY HOST PLANTS. In addition to sprouted corn, several other host plants were tried as larval food in the rearing vials. Stems of squashes, cucumbers, cantaloupes, watermelons, roots of hairy vetch, and Austrian peas were used at various times. Larvae fed upon each of these host materials, but none of them proved satisfactory for use on a large scale. The sections of cucurbit stems, which were perhaps more nearly satisfactory than the others, dried out rapidly and demanded too frequent changes to be desirable. Large corn sprouts also proved to be rather unsatisfactory.

METHOD OF SPROUTING CORN. The method of sprouting corn was developed through a process of trial and error. The sprouter first used consisted of corn rolled in several layers of cheese cloth. This proved unsatisfactory, however, as the cloth dried out rapidly and the roots of the corn, growing into the meshes of the cloth, became entangled. Absorbent cotton was then placed on the inside of the bundle between the cheese cloth and the corn. This furnished an abundance of moisture, but the problem of freeing the entangled roots (in this case from the cotton) still remained. Paper towels were next tried and found to be satisfactory.

METHOD OF RECORDING. Since three or more generations a year occurred, and some of these generations over-lapped, a systematic method of keeping clear-cut records was absolutely essential. The method used in these studies will, therefore, be briefly outlined.

RECORDS OF ADULTS. Only one adult was placed in each vial for the regular life-history work, while several adults were confined in a single vial for certain other phases of the biological studies. The number of beetles used for the detailed life-history work was necessarily small. Consequently, a large series of numbers for these individuals was not needed and the letters of the alphabet were used. Over-wintered adults were numbered A, B, C, etc., to Z, then AA, BB, CC, etc., AAA, BBB, CCC, etc., until all were recorded. Likewise, first generation adults were numbered 1A, 1B, 1C, etc., and second generation adults, 2A, 2B, 2C, etc.

In keeping the records, regular field-note sheets 4 x 6 inches were used. In the upper left hand corner of the sheet was written the number of the beetle. Immediately below the number was a sign designating the sex, and to the right was the number of the larva from which the adult had developed. The notes on the beetle's activities were made on the lower portion of the card. Duplicate records on certain activities (such as copulation and oviposition) were kept, one record on

the card for the individual involved, and one under a general heading corresponding to the activity.

RECORDS OF IMMATURE STAGES. Eggs were numbered and recorded according to the female depositing them. For example, 1A deposited 19 eggs on May 7. These eggs were placed in an incubation vial labeled 1A.1. A record was made on the card for 1A and also on the general "oviposition" card for May 7. Eggs of the next oviposition were placed in a vial numbered 1A.2 and recorded in the same manner as the first. Upon hatching, the larvae in 1A.1 were numbered consecutively 1A.1–1, 1A.1–2, etc., and in 1A.2: 1A.2–1, 1A.2–2, etc. Each larva was placed in a separate rearing vial and a record made for it on a card. In addition to this, a record of all larvae emerging on that date was made on the general "hatching" card. The necessary information was recorded by dates on the individual larva card. The first individual to emerge was transferred to a vial for adults and labeled 2A. Later emerging beetles were numbered 2B, 2C, etc., in like manner. On the card for a newly-emerged adult was written not only the number of the adult, but also the number of the larva (say for example, 1A.1–12). This number was written in small letters and enclosed in parenthesis.

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A PRELIMINARY REPORT ON ARSENICAL SUBSTITUTES FOR PEACH SPRAYING

By S. MARCOVITCH, W. W. STANLEY and M. V. ANTHONY,[1] *Tennessee Agricultural Experiment Station*

ABSTRACT

Since the insect pests of peaches are becoming increasingly important each year in Tennessee, a study of the newer spray materials such as cryolite and barium fluosilicate was made. These were compared with the standard lead arsenate. The latter material gave foliage injury at Kingston, Tennessee, whereas the fluorine compounds were found safe, when used at the rate of one pound to fifty gallons of water. The largest percentage of sound fruit, 81.11 per cent, was recorded for plot 7 receiving a dust of 50 per cent barium fluosilicate and 50 per cent sulphur. The plots sprayed with cryolite and barium fluosilicate showed 77.6 per cent sound fruit as compared with 68 per cent with lead arsenate and 5.8 per cent in the check plots. The fluorine sprays and dusts were decidedly more efficient than lead arsenate against the Oriental moth.

Peach foliage is known to be unusually sensitive to injury by the lead arsenate used for the plum curculio. The control of this pest leaves much to be desired, necessitating the use of supplementary measures such as cultivating, picking up drops, and clean-up measures. These factors, together with the arsenical residue problem, have forced us to seek a possible substitute for lead arsenate that could be safely used in the regular spray schedule. The 1929 season's experimental work indicated that among the host of fluorine compounds, both cryolite and barium fluosilicate were the most promising arsenical substitutes for bean beetle control. These compounds were therefore selected for use in 1930. Since no intensive studies on peach insects have ever been made in Tennessee, we endeavored to determine the necessary life-history data to enable us to draw up a spray schedule to meet the requirements of the Tennessee growers.

Very little is known of the chemistry of the fluorine compounds. In planning the study it was therefore essential to determine the characteristic physical and chemical properties of the selected fluorine compounds. This phase of the problem is being investigated by the Associate Chemist, Mr. G. A. Shuey.

PHYSICAL AND CHEMICAL PROPERTIES OF CRYOLITE.—G. A. Shuey. Two forms of cryolite, natural and synthetic, are now available in commercial quantities. The natural cryolite occurs in Greenland as a native fluoride of sodium and aluminum. The powdered natural cryolite is heavy and is not so well adapted for insecticidal purposes. This

[1]Mr. J. L. Vandiver assisted with the experimental work in spraying and dusting.

past season an air-floated natural cryolite was supplied by the Pennsylvania Salt Manufacturing Company, of Pittsburgh. Their product is much lighter, approximating the density of hydrated lime.

The synthetic cryolite was supplied by Jungmann and Company, of New York City. Their product is now available in commercial quantities. The synthetic form is light and nearly uniform in composition. Both the natural and synthetic cryolite are more or less transparent in water suspensions. It was found that the refractive indices of water and cryolite are nearly identical, making cryolite appear as a soluble substance. This similarity would tend to mislead the layman into the belief that cryolite suspensions are not adapted as spraying materials.

Another synthetic cryolite was also submitted by a chemical company. When suspended in water this material is very opaque and would lead one to suspect that it possesses very desirable insecticidal properties. The chemical analysis, however, in Table 1 actually shows that it is more soluble, in spite of the high percentage of impurities. This was also corroborated by the field tests, which showed somewhat more foliage injury. In the experimental work, we confined ourselves to Jungmann's synthetic cryolite and the air-floated natural cryolite furnished by the Pennsylvania Salt Manufacturing Company. Both forms tend to absorb moisture on standing, making them difficult to use as a dust. This objection may be overcome by mixing the cryolite with a small amount of talc just prior to dusting in the field.

TABLE 1. PHYSICAL AND CHEMICAL PROPERTIES OF DIFFERENT CRYOLITES

	Solubility in Water	Size of Particles	Per cent Fluorine	Per cent Cryolite	Per cent Impurity
Synthetic cryolite (Jungmann)	1–2976	1–2 u	51.19	94.26	5.74
Synthetic cryolite	1–2463	1–5 u	44.09	81.20	18.80
Natural cryolite (Penn. Salt Mfg. Co	1–3048	1–5 u	50.22	92.49	7.51

EFFECT ON FOLIAGE. Foliage injury has always been a stumbling block in the control of peach pests by spraying. A survey of the literature indicates that New Jersey and Georgia have repeatedly called attention to the subject. Emphasis is placed on the advisability of giving no more than three sprayings with lead arsenate, as defoliation may follow if four or more applications are made (Snapp, 1924).

Mogendorff (1925) found that gypsum mixed with lead arsenate was a better agent than hydrated lime for preventing foliage injury.

In evaluating the possible effect of high humidity, intense sunlight, and high temperature, Ginsburg (1926) found that these factors play

an insignificant role, but may cause arsenical injury indirectly by increasing the permeability of plant tissue to water-soluble arsenic.

Van der Meulen and Van Leeuwen (1927) found that slaked lime added to lead arsenate prevents foliage injury by "soluble arsenic." After the lime has been carbonated, the "soluble arsenic" increases very materially.

In 1929 Swingle reported that the minimum concentration of arsenic acid toxic to peach foliage contains .0012 per cent arsenic pentoxide. The arsenic was found to act as a cumulative poison within the peach leaves. Acid lead arsenate when used alone in the proportion of one pound to 50 gallons caused very severe injury even when soluble arsenic was as low as .04 per cent as arsenic pentoxide. Apparently the soluble arsenic can not be sufficiently reduced to prevent burning.

Snapp (1928) tried out sodium fluosilicate at the rate of 2 pounds to 50 gallons of water. This material was found very toxic to the curculio and the fruit and foliage of the peach.

In our experimental work to determine the effect of lead arsenate on peach foliage under Tennessee conditions, plots were laid out for the three regular lead sprays, while others were given four lead sprays. In the plots at Kingston, 40 miles west of Knoxville, four lead sprays produced almost complete defoliation by August 4. Some trees were even showing some defoliation where only three lead sprays were applied.

On the other hand, the cryolite-sprayed plots showed no trace of injury. As high as seven cryolite sprays both in 1929 and 1930 failed to reveal the slightest degree of burning when used at the rate of 1 pound to 50 gallons of water. Barium fluosilicate appeared to be about as safe as cryolite, but with fish oil, evidence of defoliation was apparent.

The comparative effects of arsenic and fluorine were also tested in the dust form. A pure lead arsenate dust produced complete defoliation. Pure cryolite and barium fluosilicate dusts showed only traces of injury. A sodium fluosilicate dust with 50 per cent sulphur gave slight to moderate defoliation. A post-harvest dust of pure cryolite, pure barium fluosilicate, pure lead arsenate, and an 80 per cent sodium fluosilicate made September 2 produced no visible injury.

Bacterium pruni was prevalent in the Kingston orchard, and a very noticeable reduction of this bacterial disease was observed in the cryolite-sprayed plots.

EXPERIMENTAL. The University peach orchard on the Cherokee farm at Knoxville was used for one set of experiments. A block of 38 trees in one corner of the orchard was divided into 15 plots. All sprays were applied at the rate of one pound to 50 gallons of water, according to the

New Jersey dry-mix formula, using 8 pounds of sulphur and 8 pounds of lime. With the fluorine dusts, talc was substituted for the lime.

The effectiveness of the various materials used was determined by cutting open the matured fruit at harvest time, and ascertaining the percentage of drops infested by the curculio. Table 2 gives the results obtained from the drops gathered on each plot, and the percentage of infestation. The trees sprayed with lead arsenate showed an average infestation of 9.93 per cent, those sprayed with fluorine showed 6.96 per cent, while those trees that received no protection averaged 56.44 per cent curculio. The smallest number of wormy drops, 1.54 per cent, was recorded in plot 4, where barium fluosilicate was used as a spray. In the dusted plots the best results were obtained by a 50 per cent barium fluosilicate dust, showing only 3.34 per cent infestation. The 5 per cent dusts of lead arsenate or 10 per cent cryolite gave poor protection, indicating that stronger dust mixtures are necessary for efficient control.

TABLE 2. SUMMARY OF PERCENTAGE OF DROPS INFESTED BY CURCULIO LARVAE IN SPRAYING AND DUSTING EXPERIMENT WITH LEAD ARSENATE AND FLUORINE COMPOUNDS AT KNOXVILLE

Treatment	Compound	Percentage of Infestation	Number of Drops
None (check)	None	55.6	3,124
Sprayed	Lead arsenate	9.93	463
	Fluorine	6.96	1,723
Dusted	5% lead arsenate	25.23	1,379
	10% fluorine	10.35	3,138
	50% fluorine	3.34	——

Table 3 shows the results obtained by cutting open each peach, and presents the data on the percentage of curculio, Oriental moth larvae, brown rot, scab, and sound fruit. In all, 17,679 peaches were sliced and examined. The largest percentage of sound fruit, 77.6 per cent, was recorded for the fluorine sprays, while the lead arsenate gave 68.01 per cent, and the unsprayed plots only 5.9 per cent. These results were obtained with five arsenical sprays against only four fluorine sprays.

There was little difference in control of the curculio by the lead arsenate or fluorine sprays, but the latter showed more efficiency against the Oriental moth larvae. The infestation in the check plots average 60.9 per cent curculio. The lead arsenate sprays reduced this figure to 8.66 per cent, while the fluorine sprays gave only 8.73 per cent curculio. As to the Oriental moth, 48.1 per cent of the fruit was infested by this insect. In the lead plots 23.6 per cent was infested, while only 13.44 per cent was found in the plots sprayed with fluorine compounds. The best reduction in infestation was shown by the 50 per cent barium fluo-

silicate dust when the curculio percentage was 7.0 per cent and the moth larvae only 8.72 per cent.

Cryolite and linseed oil and talc gave 11.49 per cent curculio, 7.76 per cent Oriental moth larvae, and 77.2 per cent sound fruit.

TABLE 3. SUMMARY OF RESULTS OF ARSENICAL COMPOUNDS AS COMPARED WITH FLUORINE COMPOUNDS WHEN USED AS SPRAYS AND DUSTS ON FRUIT HARVESTED FROM ORCHARD IN 1930.

Percentage of Fruit Having—	Check Plots	Fluorine Sprays	Arsenical Sprays	Fluorine Dusts—10%	Fluorine Dusts—50%	Arsenical Dusts—5%
Curculio larvae	27.0	7.43	7.99	33.5	10.2	23.89
L. molesta larvae	23.3	12.24	22.04	21.3	12.1	25.0
Brown rot	0.8	.4	.37	1.61	1.47	0.18
Scab	0.4	x	x	0.03	0.14	x
Curculio and L. molesta larvae	16.9	0.5	6.7	3.43	0.7	2.52
Curculio larvae and brown rot	12.9	0.8	x	5.20	1.2	3.32
Curculio larvae and scab	4.1	x	x	0.03	x	x
L. molesta larvae and brown rot	5.8	0.71	0.89	1.61	1.8	1.29
L. molesta larvae and scab	2.1	x	x	0.03	x	x
Brown rot and scab	0.5	x	x	x	x	x
Cat-faced	x	0.1	x	x	0.5	x
Sound	5.8	77.6	68.01	33.0	72.32	43.78

DISCUSSION. The control of the plum curculio by lead arsenate alone is far from perfect, especially in the South. In order to get a high percentage of sound fruit, supplementary measures must be resorted to, such as cultivating, picking up drops, jarring, and clean-up methods. Perhaps the main reason for the difficulty experienced in combating the curculio by lead arsenate is the fact that the adult weevil feeds principally on the inside of the fruit and very little on the poisoned foliage.

The experiments of previous investigators all point to the superiority of spraying over dusting for the curculio; yet the cotton boll weevil, with similar habits, and related to the plum curculio, is best controlled by a dust of calcium arsenate. Grossman (1928) observed that the boll weevil drags its snout over the plant as it crawls. Since the snout is moist, particles of the poison adhere to it and are finally swallowed during the process of feeding within the square or boll. The boll weevil thus accidentally swallows the material in the dust form. With a sprayed surface, the chemical is literally glued or varnished onto the leaf surface, which must actually be eaten to produce mortality. Why then does spraying work better for the curculio? The answer seems to lie in the sensitiveness of peach foliage to arsenicals, which when used in the

dust form must be diluted 20 times to avoid injury. Such a highly diluted dust is naturally much less toxic to the curculio.

Cage tests show that two to three weeks are required to kill the curculio when allowed to feed on foliage sprayed with lead arsenate at the rate of 1 pound to 50 gallons of water. A pure dust of cryolite or barium fluosilicate, however, will cause practically 100 per cent mortality within two or three days, without appreciable foliage injury. Since a pure lead arsenate dust is unsafe to use on peaches, the advantage of being able to use a fluorine dust in the pure state that is highly toxic to the adult curculio is obvious. In support of this theory, a 50 per cent dust of barium fluosilicate in one field test showed the highest percentage of sound fruit.

In addition, all the experiments to date indicate that dusting gives better control of the Oriental moth. If then a dust can be found that will also give good control of the curculio, the odds will all be in favor of dusting peaches rather than spraying. The evidence to date also indicates that a fluorine residue on peaches would be very much less objectionable than arsenic.

The experimental work of the past season with fluorine compounds for the control of peach insects would seem to have the following advantages over lead arsenate: (1) They can be used in the dust form more effectively than sprays, (2) they are not noticeably injurious to foliage, and (3) they leave a comparatively harmless residue.

We are fully aware that these conclusions are drawn from only one season's work. Yet they seem sufficiently promising to justify their being brought to the attention of others who might like to try out cryolite or barium fluosilicate in their experimental work.

SUMMARY. At the present time lead arsenate is recognized as standard material for the control of the plum curculio on peach. Two fluorine compounds, cryolite and barium fluosilicate, were used in a series of tests for comparison with lead arsenate.

No foliage injury was produced by lead arsenate at Knoxville. At Kingston severe defoliation resulted from four lead sprays, and considerable from three.

No injury whatever was noticeable on those trees receiving the cryolite or barium fluosilicate at the rate of 1 pound to 50 gallons of water.

The fluorine sprays gave the largest proportion of sound fruit, 77.6 per cent, as compared with 68.01 per cent from the lead arsenate and 5.8 per cent in the check plots. There was little difference in control of the curculio by the lead arsenate or fluorine sprays, but the latter showed more efficiency against the Oriental moth larvae.

The largest percentage of sound fruit, 81.11 per cent, was recorded for plot 7, receiving a dust of 50 per cent barium fluosilicate and 50 per cent sulphur. The 10 per cent dusts of cryolite and barium fluosilicate and 5 per cent lead arsenate gave poor control.

In the untreated trees the number of wormy peaches caused by the curculio was 60.9 per cent, while the Oriental moth larvae produced 48 per cent. The fluorine sprays and dusts were especially effective in reducing the damage caused by the Oriental moth larvae.

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OBSERVATIONS ON THE BIOLOGY OF THE PEACH BORER IN ROANE COUNTY, TENNESSEE, HARRIMAN, TENNESSEE, 1930

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ABSTRACT

This paper reports observations on the biology of the peach borer in Eastern Tennessee during the summer of 1930. The emergence of adult peach borers began June 20th and continued until September 22nd. The peak of emergence occurred in the latter half of August. The potential oviposition of the peach borer is high, the average of nine moths examined being in excess of 700 eggs. Oviposition frequently begins within twenty-four hours after adult emergence. While the work of predators was quite evident it is not considered to be of economic importance.

Observations on the emergence of adults of the peach borer (*Aegeria exitiosa* Say) in the Roane County peach district were undertaken primarily to ascertain the limits and the peak period of emergence. The topography of this district is sufficiently different from that of adjacent areas to render it possible that this divergence might be reflected in the lives and habits of its fauna.

On June 14th the litter and weeds were cleared from beneath 100 peach trees in the Rose Brothers Orchard. This orchard contains 10,000 five-year-old Elberta trees. It is approximately seven miles south of Harriman, Tennessee. There was no treatment for borer control in 1929. Every tree examined in 1930 showed the evidence of borer attack.

In the process of removing the rubbish from beneath the trees several pupae were found on June 14th. Observations were started at once and made at frequent but irregular intervals. The emergence of adults was determined by the presence of the cast pupal skins. The first emergence was noted on the examination of June 20th. On June 22nd three adults were observed on the wing in the orchard and from this date until the end of the season they were frequently observed.

TABLE 1. EMERGENCE OF PEACH BORER ADULTS IN THE ROSE BROTHERS ORCHARD, HARRIMAN, TENNESSEE, 1930

Date	Number Emerged	Date	Number Emerged	Date	Number Emerged	Date	Number Emerged
June 20	1	July 17	2	Aug. 16	7	Sept. 6	18
July 1	1	18	4	19	34	8	18
8	2	19	1	22	15	12	8
9	3	21	2	25	54	16	2
11	2	Aug. 6	5	27	19	19	1
14	3	9	5	30	33	22	1
15	3	13	24	Sept. 1	21		—
16	3	15	15	4	8	Total	315

The emergence was rather light until the 13th of August. In the 30 days between August 9th and September 8th 84 per cent of the season's emergence occurred. These trees were treated for borer control September 23rd and subsequent observations were prevented. The approximate dates of emergence of 315 peach borer adults, extending from June 20th to September 22nd, a period of 95 days, are given in Table 1.

INSECTARY REARING. On June 18th a stock of mature larvae and pupae was obtained from the soil at the base of the trees. From time to time fresh material was added to this supply.

The first adults emerged June 21st and emergence continued without any interruption, more than that due to the exhaustion of the stock in the cage, until September 16th. No difficulty was experienced in obtaining an abundance of material until the latter part of August. The last collection of pupae was made August 26th. The number and sex of the moths that emerged each month are given in Table 2.

TABLE 2. INSECTARY EMERGENCE OF PEACH BORER ADULTS AT HARRIMAN, TENNESSEE, 1930

Month	Insectary Emergence		
	Males	Females	Total
June	4	3	7
July	68	32	100
August	79	88	167
September	27	40	67
Total	178	163	341

OVIPOSITION. Newly emerged insectary-reared females were confined in either vials or petri dishes for oviposition records. The moths were transferred to fresh dishes and the eggs counted daily. Conditions of confinement were such as to render it doubtful if as many eggs were formed as would have been if the moths had been at liberty.

TABLE 3. OVIPOSITION BY INDIVIDUAL PEACH BORER MOTHS AT HARRIMAN, TENNESSEE, 1930

Moth No.	Length of Life in Days	Number of Eggs Laid	Maximum in One Day	Dissection Count	Potential Oviposition
1	7	161	45	676	837
2	8	553	161	154	707
3	9	611	229	216	827
4	4	218	121	545	763
5	3	128	60	578	706
6	4	218	102	439	657
7	5	151	62	594	745
8	3	41	33	369	410
9	4	352	167	348	700
Total	47	2,433	980	3,919	6,352
Average	5.2	270.3	108.9	435.4	705.8

The length of adult life varied from a minimum of two days to a maximum of nine days. At the death of a moth a dissection was made and the number of eggs found was added to those deposited to give the potential oviposition. The individual oviposition record of nine moths is given in Table 3.

If newly emerged females are dissected the eggs will be found incased in a number of tubular membranes. They are very similar in appearance to a string of beads. The eggs at this time are arranged in a graduated series, the larger dark brown or red eggs at one end of the tube gradually decreasing in size and becoming lighter in color until at the opposite end of the string they are quite minute and translucent. In all probability additional ova are in the process of development at this time.

The eggs remaining within the abdomen at the death of a female moth which has deposited a greater or less number have apparently no system of arrangement. The membranous tubes have disappeared. The eggs and the viscid fluid fill the greater part of the abdomen. The eggs are practically uniform in size and color. No minute translucent eggs were found in the dissections at this stage.

Eggs were freely deposited at the insectary from July 25th until September 22nd. On several occasions it was noted that moths would start oviposition within 24 hours of their emergence. The last eggs were laid at the insectary September 22nd, and the last insectary-reared female died September 23rd.

Repeated attempts to measure the period of incubation resulted in failure. Apparently the eggs were infertile. No moths were observed mating in any of the breeding cages.

PARASITES. On two occasions numerous parasites of the peach borer were observed in the cage used for moth emergence. These were determined by Mr. R. A. Cushman, of the Bureau of Entomology, as *Microbracon sanninoideae* Gahan.

PREDATORS. On July 20th it was observed that some predator was digging the pupae from the soil at the base of the trees in the block under observation. This attack on the pupating forms continued with increasing severity. On August 22nd twenty clearly defined excavations, most of them showing the despoiled cocoon at their extremity, were counted about the base of one of the trees. No trees in the vicinity of the block under observation were observed to escape this attack.

No conclusive evidence as to the identity of this predator was obtained. From the fact that the marauder was not seen during the time spent in making observations it is felt that a nocturnal individual is

indicated. The size and shape of the excavations were such as could have been made by mice or similar animals.

From the extent in time of this attack and the large number of excavations found it is probable that considerably over half of the mature peach borer larvae failed to emerge for this reason.

In obtaining the stock of immature forms used in the insectary it was noted that very few larvae or pupae could be taken beneath a tree showing evidence of the recent work of this predator. Apparently these individuals possess the ability to determine the location of the larvae or pupae in the soil sufficiently accurately to enable them to remove practically all of the borers in cocoons at the time of the visit.

The value of the work of this predator in the natural control of this pest is a subject of considerable interest. However, as a control measure of relatively high efficiency is available in paradichlorobenzene the economic importance of this predator's attack is greatly reduced. It is possible that this attack may occur only on occasions in which an exceptionally heavy infestation is found. If such is the case the economic value of this work disappears entirely.

Rather late in the season barriers of screen wire were installed about the base of three of the trees. While these trees were watched carefully no signs of subsequent attack were noted, but fresh excavations continued to appear about unprotected trees in the immediate vicinity.

RESULTS OF SPRAYING AND DUSTING EXPERIMENTS FOR THE CONTROL OF THE CURCULIO ATTACKING PEACHES DURING THE SEASON OF 1930

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ABSTRACT

Large plats of peach trees of from 12 by 31 to 22 by 22 rows were used for experiments to determine the comparative effectiveness of dusts carrying 5 and 10 per cent lead arsenate and the standard lead-arsenate spray and to test the value of adding fish oil to the sprays and the value of an application of lead-arsenate spray when the buds are pink. Calcium monosulphide was used with lead arsenate and no lime to note the effect on the foliage.

Heavy applications of dust (1/3 to ½ pound per tree) carrying 5 per cent lead arsenate controlled a moderate curculio infestation as well as sprays, and the dust carrying 5 per cent lead arsenate was as effective against the insect as one carrying 10 per cent lead arsenate. The standard schedule of sprays gave as good curculio control as that with fish oil added to the sprays or that with an extra application when the buds are pink. Lead arsenate when used with calcium monosulphide and no lime gave more foliage injury than when used with self-boiled lime-sulphur containing the usual quantity of lime.

The results of experiments conducted in 1929 (Jour. Econ. Ent. Vol. 23, No. 4, Aug. 1930, pp. 699–704) showed that lead arsenate applied as a spray is more effective against the curculio attacking peaches than the same insecticide applied in a dust mixture, and that the petal-fall spray, applied when 50 to 75 per cent of the petals have fallen, is an important part of the spray schedule. Since some peach growers desire to continue to use dust, if it can be relied upon to give curculio control, it was decided to test, during the 1930 season, the effectiveness of dust when it is applied to the trees in a heavier dosage than is ordinarily used. Although previous experiments have shown no better control from 10 per cent lead arsenate in a dust mixture than from 5 per cent, which has become standard, a dust schedule calling for the 10 per cent formula was tested again against the standard dust schedule. The value of an application of lead-arsenate spray when the buds are pink and the value of the addition of fish oil to the sprays were also tested in 1930. Calcium monosulphide was used with lead arsenate without lime in one application to note the effect on the foliage.

Orchard used for Experiments in 1930. A seven-year-old Hiley orchard near Fort Valley, in the heart of the Georgia peach belt, was used for the experiments. It contained 1,583 trees most of which were in a good state of productivity, and was bordered on three sides by cultivated fields and on the fourth side by the Elberta orchard which was used for the experiments in 1929 but which failed to set fruit in 1930. The plats were headed into this adjoining Elberta orchard so that no plat was subjected to more sources of curculio infestation than another. There were no wooded areas or uncultivated fields near by to subject any part of the orchard to such favored places of hibernation. It was an ideal place to test the effectiveness of the several schedules of arsenical treatments.

The general curculio infestation in the Georgia peach belt was very heavy in 1929, in fact the second heaviest that had ever occurred in that district. That provided a good source of reinfestation for 1930. Jarring records obtained when the curculio beetles began to leave hibernation in the spring of 1930, to ascertain the extent of infestation in the experimental orchard, showed as many as 6 curculios per tree. The experiments were therefore conducted in an orchard in which the curculio infestation at the beginning of the season was moderate and about the average for the district.

Schedules Tested and History of Applications. The orchard was divided into five large plats. Plat 1 (12 by 31 rows) contained 328 trees, plat 2 (14 by 30 rows) contained 323 trees, plat 3 (14 by 29 rows)

TABLE 1. SCHEDULES TESTED, QUANTITY OF INSECTICIDES USED, AND DURATION OF APPLICATIONS; PEACH SPRAYING AND DUSTING EXPERIMENTS, FORT VALLEY, GA., 1930

Plat No.	Treated with	When Buds are Pink			When 75 per cent of Petals are Down			When Calyces are Shedding			Two Weeks after Shedding of Calyces			Four Weeks before Harvest		
		Insecticide	Total quantity applied	Duration of application	Insecticide	Total quantity applied	Duration of application	Insecticide	Total quantity applied	Duration of application	Insecticide	Total quantity applied	Duration of application	Insecticide	Total quantity applied	Duration of application
I	Dust				0–5–95	55 lbs.	35 min.	0–5–95	122 lbs.	27 min.	80–5–15	154 lbs.	33 min.	80–5–15	144 lbs.	37 min.
II	Dust				0–10–90	45 lbs.	38 min.	0–10–90	104 lbs.	32 min.	80–10–10	150 lbs.	31 min.	80–10–10	132 lbs.	34 min.
III	Spray				A.L.+L.	185 gals.	1 hr. 38 min.	A.L.+L.	250 gals.	2 hrs. 37 min.	S.B.	210 gals.	1 hr. 50 min.	A.L.+ S.B.	300 gals.	2 hrs. 32 min.
IV	Spray				A.L.+L. +F.O.	190 gals.	1 hr. 37 min.	A.L.+L. +F.O.	250 gals.	2 hrs. 25 min.	S.B.+F.O.	225 gals.	1 hr. 57 min.	A.L.+ S.B.	260 gals.	2 hrs. 22 min.
V	Spray	A.L.+L.	190 gals.	1 hr. 56 min.	A.L.+L.	180 gals.	1 hr. 37 min.	A.L.+L.	245 gals.	2 hrs. 13 min.	S.B.	203 gals.	1 hr., 55 min.	A.L.+ CaS.	250 gals.	2 hrs., 13 min.

0– 5–95 = Lead arsenate 5 per cent, hydrated lime 95 per cent.
0–10–90 = Lead arsenate 10 per cent, hydrated lime 90 per cent.
80– 5–15 = Sulphur 80 per cent, lead arsenate 5 per cent, hydrated lime 15 per cent.
80–10–10 = Sulphur 80 per cent, lead arsenate 10 per cent, hydrated lime 10 per cent.
A.L. = Lead arsenate powder 1 pound to 50 gallons of spray.
L. = Milk of lime from 4 pounds of hydrated lime to 50 gallons of spray.
F.O. = Fish oil at the rate of 4 fluid ounces to 50 gallons of spray.
CaS. = Calcium monosulphide at rate of 6¼ pounds to 50 gallons of spray.
S.B. = Self-boiled lime-sulphur 8–8–50.

contained 307 trees, plat 4 (17 by 27 rows) contained 305 trees, and plat five (22 by 22 rows) contained 320 trees. Table 1 gives the schedules that were tested on these plats, the quantity of the insecticides used, and the duration of applications.

Each application was given to the five plats on the same day. The dusting was started at sun-up in the morning, which is usually the calmest time of the day, and the spray was applied when the wind, if any, was very light. The dusts were applied with a power duster equipped with a 3½ H. P. engine and the sprays were applied at a constant pressure of 225 pounds with a power sprayer equipped with a 3 H. P. engine.

All of the dust treatments except the first were applied at a rate of from one-third to one-half pound per tree. The usual dosage is one-fifth pound per tree for formulae carrying 90 or 95 per cent of hydrated lime, and one-fourth pound per tree for formulae carrying 80 per cent of sulphur.

RESULTS. Ten trees of average size were selected in the center rows of each plat as record trees. As there were ten or more barrier rows between the record trees of each plat, there was no danger of a drift of dust or spray from an adjoining block to the record trees. All of the drops that fell from the record trees were collected at intervals of four or five days and cut open to determine the percentage infested by the curculio, as the adults that develop from infested drops deposit the eggs for the second brood of larvae which usually appears in the peaches before harvest. At harvest all of the fruit was taken from the record trees and cut open to ascertain the exact percentage of the matured fruit damaged by the curculio.

Table 2 gives the results obtained from the examination of drops from the record trees in each plat.

TABLE 2. NUMBER OF PEACH DROPS, AND PERCENTAGE OF THEM INFESTED BY CURCULIO; SPRAYING AND DUSTING EXPERIMENTS, FORT VALLEY, GA., 1930

Plat	Treatment	Total Number of Drops Examined	Total Percentage of Drops Infested by the Curculio
I	Dust, (heavy dosage) full schedule with 5 per cent lead arsenate	3,349	24.0
II	Dust, (heavy dosage) full schedule with 10 per cent lead arsenate	2,455	13.0
III	Spray, full schedule	2,025	20.2
IV	Spray, full schedule with fish oil	3,146	22.8
V	Spray, full schedule plus extra application of lead-arsenate spray when buds are pink	4,916	21.2

Neither the addition of fish oil to the sprays nor the extra application of lead arsenate when the buds were pink reduced the curculio infesta-

TABLE 3. SUMMARY OF RESULTS OF EXAMINATIONS OF PEACHES AT HARVEST; SPRAYING AND DUSTING EXPERIMENTS, FORT VALLEY, GA., 1930

Plat	Treatment	Total Number of Fruit	Percentage of total fruit having— Curculio Larvae	Brown Rot	Curculio Larvae Only	Brown Rot Only	Curculio Larvae and Brown Rot	Brown Rot Infection at Curculio Puncture	Percentage of Total Fruit Found to be Sound
I.	Dust, (heavy dosage) full schedule with 5 per cent lead arsenate	6,613	0.6	1.9	0.5	1.7	0.5	0.1	95.9
II.	Dust, (heavy dosage) full schedule with 10 per cent lead arsenate	7,388	1.3	1.1	1.2	1.0	—	0.1	96.8
III.	Spray, full schedule	5,207	1.0	1.5	0.8	1.3	0.1	0.1	96.7
IV.	Spray, full schedule with fish oil	8,529	0.9	0.9	0.8	0.8	—	0.1	97.1
V.	Spray, full schedule plus extra application of lead-arsenate spray when buds are pink	7,926	1.1	0.7	1.0	0.6	—	0.1	96.9

tion in the drops. The 84.6 per cent more wormy drops from the dusted plat which received the 5 per cent lead-arsenate formula than from the dusted plat which received the 10 per cent lead-arsenate formula did not increase the amount of curculio wormy fruit at harvest, as the first-generation adults of the 1930 season did not deposit any eggs before the Hiley peaches were picked. The percentage of curculio wormy drops from the plat which received the standard dust formula containing 5 per cent lead arsenate was about the same as that from the plat receiving the standard schedule of sprays; however, the dust was applied in heavy dosages.

Table 3 presents the results obtained from the examination of the fruit from the record trees of each plat at harvest time. A total of 35,663 ripe peaches were cut open to obtain these results.

The heavy applications of the standard dust containing 5 per cent lead arsenate controlled the curculio as well as the standard schedule of sprays; however, the infestation at harvest was only moderate, and much less than the infestation in 1929. The dust containing 5 per cent lead arsenate gave as good control of the curculio as the dust containing 10 per cent lead arsenate. The standard schedule of sprays gave as good curculio control as the standard schedule of sprays with fish oil added or the standard schedule of sprays plus an extra application of lead arsenate spray when the buds are pink. The results on brown rot were taken to show the interrelation between curculio injury and brown-rot infection. Excellent control of the disease was obtained in all plats. The percentage of curculio wormy fruit was very low in all plats, and there was a correspondingly low percentage of brown-rot infection in all plats. With the excellent curculio control all of the fungicides as used gave excellent results. The percentage of total fruit found to be sound was high for all plats. The commercial grade of fruit from these plats was the best produced in the locality in 1930. The fruit from all plats contained very little residue at harvest.

Foliage and Bud-Wood Injury. The following are the final notes on foliage and bud-wood injury in each plat as recorded on August 9, 1930, one month after the last peaches were picked.

Plat I (heavy application of dust containing 5 per cent lead arsenate). —Very light foliage injury on normal trees. Light to moderate foliage injury on weak trees. Practically no defoliation. No bud-wood injury.

Plat II (heavy applications of dust containing 10 per cent lead arsenate).—Severe bud-wood injury on north side of trees. Many buds killed on that side and also cankers as a result of arsenical treatments.

Heavy foliage injury and defoliation on weak trees. Moderately heavy foliage injury on normal trees.

Plat III (spray, full schedule).—Practically the same as in Plat I. Perhaps just a little more foliage injury.

Plat IV (spray, full schedule with fish oil).—A little more foliage injury than in Plat III, but no bud-wood injury.

Plat V (spray, full schedule with extra application before any foliage growth).—A little more foliage injury than in Plat IV, and noticeably more than in Plat III, but no bud-wood injury.

No fruit injury was observed in any plat during the season.

SUMMARY. 1. Heavy applications of dust (one-third to one-half pound per tree) carrying 5 per cent lead arsenate controlled a moderate curculio infestation as well as sprays. (Former experiments have shown that a spray is more effective against the curculio than the usual dosage of dust —one-fifth to one-fourth pound per tree.)

2. Dust carrying 5 per cent lead arsenate gave as good control of the curculio in the harvested fruit as dust carrying 10 per cent lead arsenate. While the drops from the trees treated with the 10 per cent lead-arsenate dust contained less curculio larvae than those from trees treated with the 5 per cent lead arsenate dust, the dust carrying 10 per cent of the insecticide can not be used in dosages as heavy as those tested in these experiments on account of severe bud-wood and foliage injury.

3. Curculio control in the plat which received the standard schedule of sprays was as good as that in the plat receiving the standard schedule of sprays with fish oil added or in the plat receiving the standard schedule of sprays plus an extra application of lead-arsenate spray when the buds are pink.

4. Lead arsenate, when used with calcium monosulphide and no lime, gave more foliage injury than when used with self-boiled lime-sulphur containing the usual quantity of lime.

BIOLOGICAL STUDIES OF THE ORIENTAL FRUIT MOTH

By C. O. EDDY and W. C. NETTLES

ABSTRACT

As a pest of peaches in South Carolina in 1930, the Oriental fruit moth (*Laspeyresia molesta*) was destructive in the Piedmont Section to varieties maturing after the Elberta harvest. It was not a factor in production in the Sand Hill Section at any time. At Clemson College two complete generations were produced, adults of the third and fourth generation appeared, but a portion of the larvae of these generations went into hibernation. Larvae of the fifth generation appeared but all hibernated. The first eggs appeared on April 24, the first larvae on April 29, the first pupae on May 22, and the first moth on June 2. These dates are believed to be much later than normal because of the cold, delayed spring. The first eggs which produced overwintering larvae were laid on August 15 and the last eggs of the season hatched on October 19. The last eggs that produced adults in 1930 were laid on August 31, and the last adult died on October 21 or two days after the first frost.

The following parasites were found in South Carolina in 1930:—*Arachnophaga*[a] n. sp., *Arachnophaga*[a] n. sp., *Ascogaster carpocapsae* (Vier.), *Brachmeria* sp? *hammari* Cwfd., *Cremastus tortricidis* Cush., *Dibrachys boucheanus* (Ratz.), *Eupelmus cyaniceps* var *amicus* Gir., *Eupelmus limneriae* (How), *Goniozus columbianus* Ashm., *Haltichella longicornis* Ashm., *Macrocentrus ancylivora* Roh. (introduced), *Macrocentrus delicatus* Cress., *Microbracon mellitor* (Say), *Phanerotoma*[b] species, *Dilvachys*[b] species and *Pristomerous*[b] species.

EXPERIMENTS ON CONTROLLING LARVAE OF THE PECAN WEEVIL BY CULTURAL METHODS

By THEO. L. BISSELL, *U. S. Bureau of Entomology, Experiment, Ga.*

ABSTRACT

Experiments covering one season show that larvae of the pecan weevil (*Curculio caryae* Horn) can be prevented from burrowing into the soil under pecan trees by hand raking and rolling and to a lesser degree by raking alone when such operations are performed just previous to the time of emergence of the larvae from the nuts.

The most vulnerable period in the existence of the pecan weevil larva (*Curculio caryae* Horn) is at the time it leaves the nut to burrow into the soil. Before that time the larva is hidden within the pecan nut and afterward it is enclosed within a cell which, in cultivated soil, lies about 5 inches below the surface. Though the time consumed by the larva in entering the soil is comparatively short, it is a critical period because of the exposure to which the larva is subjected.

[a]These are commonly parasites of spiders. Records from fruit moth should be carefully verified.

[b]Collected by Entomologists of the Bureau of Entomology.

For the past three years the beginning of the period of emergence of larvae from pecan nuts in the vicinity of Experiment, Ga., occurred on the following dates: October 7, 1928; September 16, 1929; October 1, 1930. Emergence continued into December and sometimes later but half the grubs were found to have left the nuts in the first two to three weeks after issue began. October 20, 5, and 18 were the dates of median emergence for the years 1928, 1929 and 1930, respectively. To the grower this is significant because the earliest harvest dates were a week or ten days after the median emergence dates, with the result that about 70 per cent of the emerging larvae left the nuts before they were harvested. By gathering the nuts sufficiently early larvae can be caught before they emerge but harvesting prematurely is very laborious and tends to reduce the quality of the non-infested nuts. Therefore, it is advisable to attempt to prevent larvae from entering the soil before the nuts are gathered. During 1930 a series of field experiments were conducted to determine the value of cultural methods in preventing larvae of the pecan weevil from penetrating the soil.

The experiments were carried out in the Georgia Experiment Station pecan orchard, with trees 23 years of age. The soil was Cecil clay loam with considerable organic matter. On August 23, 1930, the entire orchard was well harrowed so that all herbage was turned under. Three experimental plots were arranged, each occupying half the space under one pecan tree.

On September 18 Plot A was leveled and pulverized with a hand rake and on September 25 the ground was rolled several times with a hand roller weighing 263 pounds so that a well packed, even surface was formed. On September 25 plot B was hand raked to form an even pulverized surface. Plot C, the check, received no treatment after August 23.

Following rains during September a volunteer winter cover crop sprouted over the untreated ground. This had reached a height of one-half inch on October 9 and was 2 to 3 inches in height on October 17. A scattered sparse vegetation appeared on plots A and B but was avoided in the experiments. Small sticks and dead leaves were present on the untreated plot but similar matter was removed from the treated plots and was not allowed to accumulate after experiments began. Each plot was divided so that a part was exposed to sunshine and a part shaded by the tree. The factor of shade changed on some plots during the course of a test, usually two or three hours after it was begun.

The larvae used in the experiments issued from picked pecan nuts kept in the insectary and were held in damp sand until used, usually

less than one day. Active vigorous larvae were selected for each trial. These were placed on the plots and protected from birds by a wooden frame 4 feet square by 6 inches high which was covered with chicken wire. Larvae were not allowed to burrow beside the upright edges of the cage. Observations and counts were made on an average of one hour apart to determine the number burrowing into the soil and to make certain no larvae were lost. Final counts were made within ten hours of the beginning of the experiment. The experiments were concluded during the month of October, 1930.

Table 1 gives meteorological data as follows: total rainfall for the month, sunshine on record days, air and soil surface temperatures. The air temperatures, which cover 24-hour periods, were recorded on maximum and minimum thermometers in a screened insectary 250 yards from the experimental plots. During the last four trials soil surface temperatures were obtained by placing thermometers directly on the ground by the larvae. These latter temperatures are approximate averages for the period of each test. Table 2 shows the dates on which experiments were conducted, the hour begun, the number of larvae placed on each plot and the number burrowing into the soil.

TABLE 1. WEATHER AND TEMPERATURE RECORD, EXPERIMENT, GA., OCTOBER, 1930

Date	Weather Record	Temperatures			
		Air		Soil Surface	
		Mean °F	Range °F	Sun °F	Shade °F
8	Rain, 0.33 in	—	—	—	—
9	Rain, 0.03 in. Sun after 10 A.M.	67	6	—	—
10	Rain, 0.01 in. Sun after 11 A.M.	70	12	—	—
11	Sun after 8:30 A.M.	68.5	17	—	—
17	Sun except 12–2:30 P.M.	70	22	—	—
18	Sun	53	18	—	—
20	Sun	60.5	21	—	—
22	Sun	52.5	25	—	58
27	Sun	61.5	29	94	65
28–29	Rain, 1.34 in	—	—	—	—
30	Sun and wind	50	28	69	53
31	Sun and wind	40	18	66	42

DISCUSSION AND CONCLUSIONS. The percentages of larvae burrowing in the three plots were as follows: rolled ground (A) 14.0; raked ground (B) 70.8; untreated ground (C) 86.6. Thus it is seen that fewer larvae penetrated the rolled ground as compared with the raked or with the untreated. On each plot more larvae burrowed where the ground was shaded than where the ground was not protected from the sun.

Influence of sunshine. In the laboratory larvae kept out of direct sunlight and in an atmosphere of low humidity died with a loss in weight of 50 per cent, and death was hastened by an increase in temperature.

TABLE 2. RECORD OF PECAN WEEVIL LARVAE BURROWING ON TREATED PLOTS

Date October	Time of Day Test Begun	Plot A (Rolled) Sun Total Larv.	Sun Larv. Burr.	Shade Total Larv.	Shade Larv. Burr.	Plot B (Raked) Sun Total Larv.	Sun Larv. Burr.	Shade Total Larv.	Shade Larv. Burr.	Plot C (Check) Sun Total Larv.	Sun Larv. Burr.	Shade Total Larv.	Shade Larv. Burr.
9	9:00 A.M.	—	—	25	4	25	25	—	—	—	—	—	—
10	8:30 A.M.	—	—	7	2	8	8	—	—	—	—	—	—
11	8:30 A.M.	—	—	13	6	13	12	—	—	—	—	—	—
17	9:00 A.M.	—	—	25	3	25	3	—	—	—	—	25	25
17	1:30 P.M.	—	—	25	19	25	16	—	—	—	—	25	25
18	9:00 A.M.	25	4	25	7	25	22	25	22	24	24	—	—
20	9:30 A.M.	25	6	25	5	25	24	25	22	25	24	—	—
22	10:30 A.M.	25	0	25	5	25	21	26	22	25	21	25	18
27	10:30 A.M.	35	0	35	0	35	4	35	19	35	19	35	25
30	10:00 A.M.	60	4	60	4	61	47	60	49	60	52	60	60
31	9:30 A.M.	50	6	50	0	50	38	50	27	50	47	50	40
Total larvae		220	20	315	55	317	220	221	161	219	187	220	193
Percentage burrowed			9.1		17.5		69.4		72.9		85.4		87.7
Percentage burrowed by plots				14.0				70.8			86.6		

This manner of death is called drying. It is accompanied by a change in color from cream to brown. Excessive heating by the sun affects larvae in a like manner. In the experiments protection from sunshine, as afforded by shade of the trees and by the herbage growing on plot C, was an important factor toward success in burrowing. In two trials on the sun-exposed part of the raked plot a high percentage of larvae dried before they could enter the soil. Out of 25 larvae that were placed on sunshine on plot B on the morning of October 17, 3 burrowed and 22 died within two hours. On the other hand, out of 25 grubs placed on the same ground in the afternoon during a cloudy spell 16 burrowed into the soil in 15 minutes and 9 died. Again, on October 27 most larvae dried within two hours after being placed on the soil. The temperature of the soil surface October 27 in the sunshine was 94°F while the air temperature at the same time was 70°. The ground lost much moisture during the period October 22 to 27, so that the small vegetation suffered, and on the latter date there was a low percentage of burrowing on all plots.

On October 31 more larvae burrowed in the sun than in the shade. This was evidently due to the low temperatures prevailing and to the stimulation by sunshine. The ground temperature in the sun was 66°F as opposed to 42° in the shade while the mean air temperature for the day was 40°F.

Influence of other weather conditions. Rain apparently helps larvae to burrow by softening the ground and by reducing the temperature of the soil surface. Larvae were more successful in burrowing on October 30 after the rains of the 28th and 29th than on October 27 though the low temperature of the 30th doubtless also influenced larval activity.

The high wind of the last two days of October may have been detrimental in drying larvae though they were largely protected from wind by the sides of the cages.

Influence of soil conditions. To penetrate a soil a larva must find two conditions: (a) sufficient plasticity to hold the shape of the burrow, which requires the presence of some water, and (b) sufficient friability to allow working by the larva's muscular power. Provision of leverage facilities will somewhat offset a lack of these conditions as is found in a water-free pulverized soil or in a packed soil. Pecan weevil larvae make frequent use of leverage against clods of earth, sticks and living plants.

Although the soil in plot C was inclined to dryness, part of the period conditions were nearly ideal for burrowing. There was plasticity, friability, leverage and protection from heat by the cover crop. The soil of the raked ground was friable but was dry and without protection

from heat. The soil depressions of plot B did afford leverage. The rolled ground was entered only through the few cracks present.

Speed of penetration is an important consideration as under natural conditions the longer larvae remain on top of the soil, the more subject are they to the attacks of predators as well as to the effects of weather. Of the 836 larvae that succeeded in burrowing into the ground in the whole series of experiments, 83.5 per cent were hidden within two hours after they were placed on the soil. Out of 377 of the burrowing larvae, which were more closely timed than the remainder, 61.8 per cent penetrated in the first thirty minutes after being placed on the ground. Dividing these 377 larvae by plots it was found that on the rolled ground 16 per cent, on the raked ground 59 per cent, and on the untreated ground 79 per cent, of the burrowing larvae entered the soil in the first half hour.

SOIL ANIMALS ATTACKING SUGAR CANE

By J. W. INGRAM, *Bureau of Entomology, U. S. Department of Agriculture*

ABSTRACT

A survey of the sugar-cane fields of Louisiana showed the number of soil animals and root injury to be greatest on heavy soils. The most numerous of the injurious species in sugar-cane fields was *Hanseniella unguiculata* Bagnall, with *Onychiurus armatus* Tull., *Japyx* sp., *Lepidocyrtus violentus* Fols., and *Zonitoides arboreus* Say following in the order named. After extermination of soil animals normal numbers were reached again in two years.

"Root disease" has long been a problem in sugar cane culture in Louisiana. This condition is characterized by deterioration of the root system resulting in backwardness in the growth of the cane plants and is apparently due to a combination of factors, including root-rotting fungi and possibly deleterious soil-chemical conditions as well as direct damage by species of soil fauna.

Minute animals were first linked with root diseases in Louisiana by Rands in 1924. He found the snail, *Zonitoides arboreus* Say, causing root injury by gnawing pits in the roots, which apparently furnished entrance places for root-rotting organisms. Later he found a centipede, *Arenophilus bipuncticeps* Wood, and a symphilid, *Hanseniella unguiculata* Bagnall, causing the same type of injury.

Spencer and Stracener found that three collembolans, *Lepidocyrtus violentus* Fols., *Onychiurus armatus* Tull., and *Proisotoma minuta* Tull., also injured sugar-cane roots.

In order to obtain further information concerning the role of soil animals in root deterioration, work was begun by the writer in 1929 in cooperation with the U. S. Bureau of Plant Industry on this phase of the problem.

A soil survey was made to determine the extent of injury by animals inhabiting the soil, the environmental influences upon this injury, and the soil-animal population of the different areas. Soil samples were taken monthly on four sugar-cane plantations representative of four different soil areas. On three flat-land plantations samples were taken in front-land and back-land fields of plant cane. Samples were also taken from one first-year stubble field on each of these plantations. The fourth plantation was located in the hill section near Broussard, Louisiana, and samples were taken in hill and valley fields of plant cane and in a hill stubble field. In order that the effects of the influencing factors might be as uniform as possible fields of the variety P. O. J. 213 were selected for sample taking whenever possible.

The soil samples taken were 4 inches long by 4 inches wide by 8 inches deep. They were taken from the top of the row and one cane plant was included in each sample.

The average numbers of the principal soil animals found in a sample 4 inches square taken from various soil areas were as follows:

Soil Animal	Houma	Franklin	Westfield	Broussard	Average
H. unguiculata	14.33	10.58	5.74	5.08	8.93
L. violentus	3.32	2.03	3.50	.92	2.44
O. armatus	4.60	4.83	1.83	4.39	3.91
Japyx sp.	3.73	5.19	2.15	2.07	3.29
Z. arboreus	1.48	.23	6.72	.04	2.12
Total fauna	37.56	27.59	24.01	18.27	26.86

(All forms of animal life in the soil except ants)

The largest populations of soil-inhabiting animals were generally found in the heavier types of soil with about equal numbers in fields of plant and stubble cane. Of the soil animals known to feed upon sugar cane the most numerous one, the symphilid, was decidedly more abundant in fields of stubble cane as compared with fields of plant cane. It also showed a preference for the heavier soils. The springtail *L. violentus* was most numerous in plant cane and was about equally numerous in heavy and light soils. The springtail *O. armatus* showed a preference for plant cane and the heavier types of soils. The bristletail *Japyx* sp. was most numerous in stubble cane but showed little preference as to the various types of soil. Apparently *Japyx* sp. is here recorded for the first time as injurious to sugar cane in Louisiana. The small snail *Z. arboreus* was most numerous in stubble cane but showed little apparent preference for any particular type of soil.

Determinations of hydrogen ion concentration were made from the different samples of soil, but little correlation was found between the alkalinity or acidity of the soil and the number of soil animals present.

Sugar-cane roots were examined with each sample of soil. It was found that injury by soil animals to sugar-cane roots was in proportion to the number of animals present and that root injury was heaviest on the heavier types of soil. Owing to the small number of roots in the spring, injury at that time was heavier than later in the season. Plant cane suffered more root injury than stubble cane.

Soil samples were taken from the second 8 inches in sugar-cane fields, but the number of soil animals found was too small to have appreciable influence on the amount of root injury.

By taking soil samples in fields of soybeans and corn which were being rotated with sugar cane, it was found that in heavy soils the population was greater than in sugar-cane fields on the same type of soil. Symphilids were more numerous in sugar-cane fields and collembolans were more numerous in corn and soybean fields. On the average, collembolans thrived better in poorly drained soils than did the symphilids.

H. unguiculata, *L. violentus*, *Japyx* sp., *Z. arboreus*, a species of earwig, and two species of millipedes have all been observed feeding upon cane roots. With the aid of a hand lens *L. violentus* has been observed "grazing" upon root hairs of the cane plant. *L. cyaneus* has been observed feeding upon a fungus that grows upon sugar cane in sprouting boxes.

To determine the preference of foods by different soil animals various species were released in jars of sterile soil and possible foods added. All forms survived on newly cut cane stalks.

H. unguiculata did not live when fed wholly on sugar-cane roots. When released in sterile soil only, all species decreased in numbers. *L. violentus* was the only form that multiplied rapidly on the materials added. Ten of these springtails multiplied on sugar-cane to 215 in 7½ weeks. The same number on soaked corn increased to 3,437 in 8½ weeks. Dr. J. W. Folsom and Mr. H. B. Mills of the Delta Laboratory at Tallulah, Louisiana, found that a related species increased rapidly on parched peanuts. At their suggestion this material was tried as a food for *L. violentus* and 10 specimens in 7½ weeks increased to 3,554 on four parched peanuts. This springtail feeds upon a fungus that grows on peanuts.

Collembolans were handled with ease and rapidity by the use of a glass medicine dropper tube having the upper end covered with a cloth and inserted into a medium-size rubber bulb. Collembolans were

drawn into the glass tube and on the cloth by suction and released by pressure on the bulb with no apparent injury to the insects.

When the symphilids were released in jars of soil containing corn or peanuts they became enmeshed in the fungus growing from these materials and death resulted.

To determine the length of time required for soil animals to reach normal numbers following extermination, soils in sugar-cane fields following flooded rice were examined. Practically no soil animals were found in rice fields following drainage. It was found that the number of soil animals in sugar-cane fields following corn and soybeans was about four times as great as in such fields following a crop of rice. The root injury was in proportion to the number of soil animals present. The second year following rice, with soybeans and corn grown the first year, the number of soil animals present was practically the same as in sugar-cane fields not preceded by rice. It appears that if the injurious soil animals were destroyed benefit would be derived the year following, but the second year the soil-animal population would have reached normal numbers again.

In cooperation with the U. S. Bureau of Plant Industry the effect of chemicals upon soil animals has been noted. Certain chemicals, apparently by their repellent action, have been found to reduce materially the number of soil animals present, with a resulting increase in cane yields. Additional chemical control, life-history work, and environmental observations are being carried on in an attempt to control the soil-animal factor in the root-rot trouble.

Appreciation is expressed to Mr. T. E. Holloway, in charge of sugar-cane insect investigations, Bureau of Entomology, and to Dr. R. D. Rands of the Bureau of Plant Industry for aid and suggestions in carrying on investigations of the animals in sugar-cane soil.

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THE IMPORTANCE OF *EUETHEOLA (LIGYRUS) RUGICEPS* LEC., AN ENEMY OF SUGARCANE

By B. A. OSTERBERGER, *Assistant Entomologist, Louisiana Experiment Station*

ABSTRACT

For more than fifty years the sugar planters have known of this beetle injuring sugarcane, and the center of heaviest infestations appears to have been constantly in or around St. Mary Parish. There has been considerable question as to the amount of damage really done. Experimental work conducted at Franklin, Louisiana in 1930 shows that the destruction of the original mother stalk only in each stool would result in a decrease in yield of about 25% and a loss in sugar production of about $35.00 per acre.

This beetle was first described by LeConte in 1856, from specimens received from Georgia. It has been known to entomologists since as being of only slight economic importance. It is probable, however, that it was known to the planters as a pest of sugarcane in St. Mary Parish over fifty years ago. The first record of damage to young sugar-cane was in 1876 on the plantation of Mr. L. Swamsteadt, St. Mary Parish, Franklin, Louisiana. In 1880 Mr. Swamsteadt estimated that he had a loss of 200,000 pounds of sugar and that the loss had amounted to $25,000 in three years. Damage was found also on other plantations around Franklin, among some of them being the plantations of Messrs. E. Celon, D. Caffery, Charles Walker, Daniel Thompson and others, but in no case was the damage as serious as that on Mr. Swamsteadt's plantation.

In the course of recent sugarcane insect investigations we have found that this beetle has a state-wide distribution, but the most serious damage is still confined to the Teche section, especially in St. Mary Parish. The damage comes from the over-wintering adults which emerge and start their activity very early in the spring, usually about the first week of March. They attack the original "mother stalks" of cane just below the ground, making one or more deep ragged holes. These holes are often so large and so deep that the sap supply is completely cut off, causing a dying and yellowing of the growing region above, forming what is called a "dead heart." While the damage is more serious to young plant cane, the beetles are found attacking also young stubble cane and even mature cane. In either of the latter cases the damage is apparently very slight. There has been some question as to the seriousness of this attack on cane. The species is injurious also to stands of corn and of rice.

Last season the heaviest infestation was found at Franklin, Louisiana. This is in the section where damage has always been most severe, and here an attempt was made to determine definitely the actual loss per acre on plant cane. To do this twenty-five stools were selected with healthy, uninjured mother stalks and twenty-five adjoining stools with injured stalks. These pairs were located adjacent and all conditions were as closely comparable as possible. Each stool was numbered, the sprouts counted and measured on July 4 and again at harvesting, when weights were taken and chemical analyses were made also. In the case of six pairs the sprouts from nearby stools had so intergrown that it was impossible to determine the stool to which they belonged and so these stools were discarded in the final records.

SUGARCANE BEETLE DAMAGE TO STAND, GROWTH, AND SUCROSE CONTENT OF POJ 213 CANE AT FRANKLIN (TOTALS AND AVERAGES FOR 19 PAIRS OF STOOLS)

Original Stalks not Injured by Ligyrus					Original Stalks Killed by Ligyrus				
July 4, 1930		Dec. 5, 1930			July 4, 1930		Dec. 5, 1930		
No. Stalks	Avg. Hgt. per Stalk in.	No. Stalks	Avg. Hgt. per Stalk in.	Wt. lbs. all Stools	No. Stalks	Avg. Hgt. per Stalk in.	No. Stalks	Avg. Hgt. per Stalk in.	Wt. lbs. all Stools
199	15.9	148	79.2	289	197	13.5	123	69.3	216

Average weight per stalk in non-injured stools.....1.9 lbs.
Average weight per stalk in injured stools.....1.7 lbs.
Analyses; non-injured stools: Brix 16.50; Sucrose 13.97; Purity 84.66
injured stools Brix 16.85; Sucrose 14.61; Purity 86.70

From the results obtained in the above table, which we believe is the most accurate possible basis on which to determine the Ligyrus damage to sugar-cane, we find where the original mother stalk in each stool is injured that there is a loss of 25%, or 7 tons per acre. If the foregoing figures are carried out upon the basis of 4,000 stools per acre, which is practically a normal average, we find significant differences that are more easily understandable in dollars.

Stalks per acre, without Ligyrus.....29,600
Stalks per acre, with Ligyrus.....25,600

Decrease due to Ligyrus attack..... 4,000

Cane tonnage per acre, without Ligyrus.....28.8
Cane tonnage per acre, with Ligyrus.....21.8

Loss in tonnage due to Ligyrus attack..... 7.0 tons per acre

Value of mill cane per ton.....$ 3.50
Loss per acre in tonnage value.....$24.50
Decrease in weight of cane per acre 25%
Net loss in sugar per acre.....1,070 lbs.
Net loss in value of sugar per acre, at 3.35c.....$35.85

Among the more important references relating to damage to sugarcane are:

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SYNONYMY AND NOTES ON THE *PISSODES* WEEVIL ATTACKING *CEDRUS DEODARA*

By HENRY DIETRICH, *Lucedale, Miss.*

ABSTRACT

The Deodar Cedar, a well known Southern ornamental is seriously attacked by a weevil of the genus *Pissodes*. Hopkins, 1911, described it as a distinct species and called it *P. deodarae*. Observations show that *P. deodarae* Hopk. is not specifically distinct from *P. nemorensis* Germ., which breeds commonly in the native pines. The weevil has only one life cycle a year; adults emerging in April, aestivate until late fall, copulate, lay eggs and go thru their life history in either *Cedrus* or *Pinus*. Repellants were of no value in keeping weevils off of Deodar Cedar.

SYNONYMY. Any time after early November, especially after a rain, the Deodar Cedars in a local nursery become very heavily attacked by a weevil of the genus *Pissodes*. Naturally the source of so many weevils was puzzling as the one attacking the Deodar Cedar is supposed to be a distinct species restricted to *Cedrus* and called *P. deodarae* by Hopkins, 1911, page 52. A small sawmill about a thousand feet from the nursery was visited and the newly sawed boards were found to have thousands of the weevils on them, no different from those on the Deodar Cedars. The adults are strong fliers and could be seen flying from the sawmill to the nursery. As a result a study was made of the Pissodes weevils bred from the Deodar Cedar and native pines. A comparison of grown larvae also was made. No constant differences could be found in either the adults or the larvae. Hopkins states in his description "...but it is more distinctly separated by its habit and host. It is not improbable that this is an example of the origin of species through mutation and change of habit and host." It certainly is quite a change for a weevil commonly found in the trunks of native pines weakened from other

causes to attack thrifty and living trees of the genus *Cedrus* and kill their leaders in the manner of the White Pine Weevil. However we must take in consideration that the genus *Cedrus* is not native to North America and that a native insect may attack an imported plant just as well as an imported insect may become very injurious to a native plant. H. P. Lōding, Mobile Ala., who has had a good many years experience with both the trees and the weevils bears me out in the statement that *Pissodes deodarae* Hopk. must stand as a synonym of *Pissodes nemorensis* Germ., thus leaving only one species in the Gulf States.

NOTES. The weevils begin to appear on Deodar Cedar in late October and are present-thruout the entire winter. They can be found in copulation any time during the winter and on trees of all sizes especially in the tops and at the bases of the side branches. The weevils make punctures thru the bark with their beaks and then root like a hog. If they cannot break the bark they make a circular hole and eat out as far as they can reach but if the bark gives they eat out quite an area, sometimes girdling the leader or branch. Some of the small circular holes are used by the females for laying their eggs, usually one at a place. Leaders begin to die about the middle of January and when cut into reveal eggs and larvae of all stages. The eggs are about one millimeter long and a half of a millimeter in diameter, oval and of a creamy color. The larvae bore in the cambium layer in any direction and girdle the tree. Their galleries can be traced by the swelling of the bark. The larvae attain a length of nine millimeters and are white except for a brown head. Hopkins '11 and Bōving '29 give good drawings of Pissodes larvae, the former pointing out the characters of the larvae of *P. nemorensis*. The larvae pupate in March and the adults emerge in April. They immediately disappear, no doubt aestivating in the ground litter and do not reappear until late fall. The weevils oviposit in perfectly healthy Deodar Cedars but attack weakened trees much more severely. They usually kill the latter while a healthy tree will often lose its leader only. There is no size of the tree that the weevils will not attack. The native pines are only attacked when either dead or greatly weakened and then only on the trunk and larger limbs and roots.

Pissodes nemorensis has been found breeding in the three imported Cedars; namely Deodar (*Cedrus deodara*), Atlas (*C. atlantica*), and Cedar of Lebanon (*C. lebani*); as well as in all the pines native to South Mississippi. (*Pinus echinata*, *P. taeda*, *P. palustris*, *P. caribaea*, *P. glabra*.) Altho a good many other conifers are commonly grown in the South no injury typical of this weevil has ever been noticed. In many nurseries the different evergreens are grown side by side and altho

the Cedars will be heavily attacked none of the weevils will be found on any of the neighboring conifers.

CONTROL. No effective control has been found for this pest on *Cedrus*. Repellants such as liquid lime-sulfur, as concentrated as 1 to 4 had no affect in keeping the weevils from attacking the Deodar Cedar, whether sprayed on the whole tree or just painted on the trunk and limbs. Bordeaux mixture also was found ineffective. In no case did the materials injure the tree.

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BÖVING, ADAM G. 1929. Taxonomic characters for the identification of the mature larvae of *Pissodes strobi* Peck and *Pissodes approximatus* Hopkins. Proc. Ent. Soc. Wash. Vol. 31, p. 182–186, Plate 8.

MOUNTING COLEOPTERA

By HENRY DIETRICH, *Lucedale, Mississippi*

ABSTRACT

The paper calls attention to the value of having insects mounted properly so that they can be classified. It gives detailed directions for mounting beetles from the largest ones found in the United States measuring nearly two inches down to some smaller than pinheads. All insects should bear a label giving the locality and date of capture as well as the collector's name. An exhibit showing various size beetles properly mounted accompanied the paper.

All entomologists at some time or other have insects that they want identified. In sending them to a specialist one should have them mounted in such a way that the systematist will not have to spend a lot of time remounting. Most of us know how to mount large insects but when it comes to the small ones we are usually at a loss as to the best way. As my own specialty is the Coleoptera I shall confine my remarks to that order with the hope that specialists in other orders will give us the advantages of their experiences in mounting their particular pets.

First I want to pay my respects to my former teacher, Dr. E. C. Van Dyke who first taught me the "yucca-block" method I am going to describe and to Dr. F. E. Blaisdell Sr., who showed me the "hair-method" of mounting Coleoptera.

Beetles mounted directly on a pin have the pin thrust thru the right elytron about one-fifth the distance from the base to the tip and far enough from the median line not to crack the elytron. A No. 2 pin is the

best size to use. A No. 1 pin is somewhat too slender and a beetle that will not go on a No. 2 should be mounted on a point. For beetles larger than Maybeetles a No. 3 pin is better. In most parts of the country any quality insect pin will do but in the damp parts, such as the Gulf coast pins made of nonrusting steel should be used. An insect pin is about 38 millimeters long and should project about 7 mm. above the elytra.

There is no strict rule when to mount a beetle on a pin and when on a point. Long slender specimens are better on a point while many short but rotund ones do very well on a pin. When in doubt use a point. These points should be cut or punched from the best grade of drawing paper, Bristol board is excellent. If cut the points should be made 8 mm. long, 2 mm. wide at the pin end and tapering to the other end, the width of which varies according to the size of the specimen to be mounted. When using a punch it is well to obtain one punching the smallest possible points. If much mounting is to be done an additional punch making a medium point is very desirable. Coleoptera points can also be bought ready made. Celluloid has been used for points but is unsatisfactory as it is too springy, gets brittle and does not allow the point to be bent to shape the beetle. Now to mount a beetle on a point.

Place a piece of balsawood on the desk in front of you, take the beetles to be mounted out of alcohol and lay them on their backs on the block. Altho it is better to collect beetles directly into a cyanide bottle they should be placed in alcohol before mounting; Staphylinids especially should be left a day or two to harden their abdomens. Then pin up the paper points to the standard height of 25 mm. The pins with the points should be lined up on the balsa block. Then with a blunt straight forceps bend the tip of the point to conform to the side of the metathorax of the specimen to be mounted. Placing a little shellac on the point and taking the pin in your left hand manipulate the beetle with your right hand by the use of curved, fine pointed forceps so that the head of the specimen is to your left and get the point just back of the right middle leg firmly against the side of the metathorax. The point must not reach the center of the sternum for often characters used in classification are on the center of the metasternum. Then pushing the head of the pin into the yucca block you bring the point firmly against the side of the beetle while the specimen is held horizontal. After arranging the beetle so that it is at right angles to the point and horizontal leave it undisturbed for from 24 to 48 hours depending on the size of the specimen. The yucca blocks are sections of the flower stem of a large yucca growing in California that are cut about five centimeters thick.

I have found shellac to be the best sticker and the most permanent. If beetles are mounted without being soaked in alcohol or left to dry thoroly after soaking in alcohol, glue may be used but you must be absolutely certain that the glue is fresh or it will not stick. Other preparations have been tried but none found any better than shellac or glue. Shellac should be the white variety and left to thicken so that it just drops off a glass rod; later a little alcohol will have to be added from time to time. An excellent shellac receptacle may be made by fastening with Plaster Paris the glass rod of a Balsam bottle into the cover and so when you take the cover off, the rod with a drop of shellac on it comes with it and after use is replaced and keeps the shellac from drying out. R. C. Shannon was the first to show me the above outfit.

When the shellac has dried remove the specimen from the yucca block and with a No. 3 or 4 pin straighten out the antennae, force the legs away from the body and clean the mouth parts if necessary. The pin should always be used as a wedge driving in the point first and never as a spring if you want the specimen to retain any of its appendages. Be sure the femur is away from the body of the beetle and the tibia and tarsi away from the femur. Do not try to make every specimen perfect but let well enough alone and you will have no accidents. If the beetle snaps off the point stick it back with glue. If the legs will not stay put, place the block away and try again after twelve hours. For beetles 1 to 2 mm. use a camel's hair brush for arranging the appendages.

For specimens one millimeter or less in length the following method called the "hair-method" has proven very satisfactory. After having pinned up some fine pointed points cut off one millimeter of the point and with a little glue stick a piece of human hair two millimeters long to it, so that half of it is on the point. Having previously allowed the beetles to be mounted to dry thoroly place a very small amount of glue on the end of the hair and immediately stick it to the beetle just back of the right middle leg. Give a little time to dry and then with a camel's hair brush straighten out the appendages. Beetles of this small size have to be worked on under a hand lens or binocular.

When a beetle is properly mounted on a point it should be to the left of the pin, perfectly horizontal and with the head away from the observer. The antennae should be out in full view and the legs away from the body. No dirt should cover the mouth parts. Grease appearing on specimens can be easily removed by immersing in ether or chloroform for a few minutes.

A mounted specimen should also have a label attached giving the locality and date of capture besides the name of the collector. Any

additional data such as host, method of capture, etc., should go on another label. For permanence it is always better to attach all data directly to a specimen rather than use reference numbers. Lastly, when identified, every specimen should have a label giving its name and by whom identified. All the labels should be printed on the best linen ledger paper so that they do not turn yellow and brittle with age. Labels may be printed with a hand stamp or small printing press using 4 point type. It is surprising, how with a little practise, you can learn to print legible labels quickly and accurately.

A collection of beetles properly mounted so that all parts of the insect can be studied and with crisp white labels are a joy to behold and any specialist would find it a pleasure to name them.

PRELIMINARY REPORT ON EVIDENCE THAT MEALY BUGS ARE AN IMPORTANT FACTOR IN PINEAPPLE WILT

By J. F. Illingworth

Abstract

This paper summarizes results covering a period of four years in Hawaii. Evidence is presented indicating that Pineapple Wilt is a disease, transmitted by the pineapple mealy bug (*Pseudococcus brevipes*, Ckll.), and that infection only takes place after the insects have fed upon diseased plants. The tremendous economic importance of the problem is gone into; and the interrelation with ants fully considered.

Tentative methods of dealing with these pests are suggested, and the further introduction of natural enemies, particularly parasites, recommended.

In this paper I wish to summarize data bearing upon the relation of ants and mealy bugs to plant failure, commonly called pineapple wilt. Evidence has gradually developed, extending over a period of four years, that these pests, especially the latter, are capable of bringing about the destruction of the crop. There appears to be no question now, but that mealy bugs, *Pseudococcus brevipes* (Cockerell), after feeding on plants suffering from wilt transmit the disease to healthy plants. On the other hand, evidence is also presented to show that mealy bugs, that have never been infected by feeding on wilt material, do not bring about the characteristic symptoms of this disease.

Wilt is a common trouble that has developed in every country where pineapples have been grown for any length of time. It has always been supposed to be due to the loss of roots, destroyed by various soil organisms. The evidence here presented leads to the conclusion that it is a specific disease. I have gone into a study of the control of mealy bugs

rather fully, for I am now convinced that our troubles are mainly due to infections spread by these pests.

DESCRIPTION OF THE DISEASE. Plants affected with wilt are very noticeable in the field. The leaves lose their turgidity, and here and there the tips begin to show a reddish or yellow color, which soon extends to the whole leaf. Gradually other leaves follow in the same way, until the entire plant eventually withers and dries up entirely.

The drying effect of the disease upon the plant is much more rapid than would result from ordinary transpiration. Furthermore, that it is not due to the death of the roots, is easily demonstrated. Large normal plants, with all soil roots removed, will remain alive and green for months collecting enough moisture in the leaf axils to maintain themselves.

Usually wilt patches are first noticed as small groups of plants that have lost their healthy, green color. Ordinarily these infection centers are first seen near the borders of fields, around rock piles, etc. Once the trouble starts, however, it appears to spread, and eventually the whole field may succumb.

Upon closer inspection of a wilting plant, it will be noticed that usually some of the inner leaves show peculiar greenish spots upon their upper surface. There is now no question but that these are caused by the feeding of wilt-infected mealy bugs. In a few cases, however, these spots did not develop on inoculated plants. Yet in every instance wilt eventually resulted.

In the field it is easy to trace the migration of mealy bugs. They do not remain in the wilted plants. As soon as the leaves become dry the insects crawl to adjoining healthy plants. These in turn become infected, and after a period of about two weeks the spots appear. These spots are the earliest indication that the plant is doomed. Wilting of the leaves takes place about two to three months later.

A brief description of these characteristic chlorophyll spots may be of use to those wishing to diagnose the disease. They begin far down in the leaf axils, where the mealy bugs feed. The chlorophyll apparently is stimulated by the bite of the insect. It soon concentrates around the individual punctures in small circular areas, varying in diameter from 3 to 7 mm. As the leaf grows, pushing these spots further out into the light, the centers become raised as if affected by a poison. The raised lumps are very noticeable to the touch at this time. They become even more evident when the leaf begins to wilt, and usually retain their darker chlorophyll centers until the whole leaf dries up. Examination of the spots by transmitted light shows that at some stage in their development, the chlorophyll is usually concentrically arranged. This can be

seen best by using a hand lens. In some instances, the centers are lighter-colored or even yellow, especially before the stage when the lumps appear upon the surface of the leaf. In older spots, just the opposite may be the case, the center darker green, surrounded by a lighter green halo.

These spots are frequently in evidence on planting material. For some time I have looked upon them with suspicion, but their relation to wilt had not been demonstrated. I am convinced now that the use of such plants accounts for the scattered wilt that we find even in our good fields.

ECONOMIC IMPORTANCE OF WILT. Wilt has been the most wide-spread and destructive disease in every country where pineapples have been grown for any length of time. The rapid decline of the industry in Florida was definitely attributed to this cause. In Hawaii, as elsewhere, wilt has shown a very decided cumulative development. This has been especially noticeable during the past two decades. In 1912, J. E. Higgins[1] discussing this trouble says: "It exists in Hawaii, but with the exception of a few fields has not caused great damage." As early as 1920, in some instances, whole fields were wiped out by this disease. The losses have continued unabated, in spite of all efforts to check them. There is now no question, but that wilt is the most serious factor curtailing pineapple production in the islands. Taking the matter into consideration from every angle—plant failures, long fallows, land abandoned, etc.—the annual losses to the industry in Hawaii, due to this disease, are tremendous. I have tried to form an estimate, and find that it runs well over a million dollars.

EXPERIMENTS REVIEWED. For many years I have been interested in our common ants, *Pheidole megacephala* Fabr., since they are valuable predators on other insects. During the past four years their relation to pineapple culture has been gone into from every angle. Early in my experience I came to the conclusion that ants could not affect the health of the plants directly. Yet their close association with mealy bugs could not be overlooked. It is this phase of their habits that has continued to occupy my attention. The discovery that mealy bugs transmitted wilt implicated ants, since they protect these pests and aid in their distribution.

I will first review the preliminary experiments, the object being to determine whether ants transmitted disease organisms:

April 26, 1927, small root cages were used with sterilized soil and

[1]Haw. Agr. Exp. Sta. Bul., No. 36, p. 30.

healthy pineapple plants. Ants were permitted to enter these freely, coming from large cages where the soil was filled with diseased roots but no wilt present. After about three months, July 28, 1927, the roots had filled the small cages; the plants remained healthy; the experiment was discontinued.

Then, larger root cages, holding one-third cubic foot of soil, were prepared in the same way, July 30, 1927. These were placed on a shelf above the cages of contaminated soil. A bridge was constructed so that ants passed freely up into the sterilized soil and among the healthy roots. After a period of nearly seven months the pineapple roots had filled the small cages. February 20, 1928, this experiment was discontinued. There was no evidence that disease had been brought in by the ants.

September 20, 1927, a project was outlined on a far more extensive scale. Our largest root cages, holding six cubic feet of soil, were used. In these there is sufficient root space for pineapple plants to be grown to maturity. The plan of the work was as follows:

1. Cages with plants growing in sterilized soil were arranged so that ants could enter them only after passing through field soil containing diseased roots.

2. Plants, growing in sterilized soil, were kept free from ants, for checks.

The first experiment with this arrangement had to be abandoned, because ants inadvertently got into the check cages.

February 25, 1928, the experiment was set up again, every care being exercised to exclude ants and other crawling insects. A photograph of the layout, taken at the end of this experiment, December 20, 1928, is shown in Plate 35. The root cages are numbered 1, 2, 3, 4. The first two were prepared with field soil intermittently sterilized with steam at 30 pounds pressure for one hour on two successive days. The plants also were treated with a solution designed to destroy insects, fungi, etc. To keep insects from coming into these cages from the ground., the supports were coated with a mixture of crude oil and creosote. Cages 3 and 4 contained untreated soil from the same field—a particularly bad wilt area. These cages soon had extensive colonies of ants that came into them from the ground. The roots of pineapples growing down against the glass, showed many of the well known troubles caused by both fungi and insects. Overripe pineapples were thrown into cage 4 from time to time to attract ants.

As soon as roots were well established in cages 1 and 2, (April 2, 1928) a small stick was used as a bridge to let insects pass from the contaminated cage 4 into the sterile cage 1. Cage 2 was maintained as a check.

1. Preliminary set-up of experiment to determine relation of ants to pineapple failure. Results implicated mealy bugs as an important agent in pineapple wilt. Cage 1 had infected mealy bugs, (2) was a check, (3) uninfected mealy bugs and (4) a dump of pineapple refuse, the source of infection for cage 1.

2. Experiment which indicated that neither ants nor mealy bugs are a serious menace to pineapple plants, unless the latter are first infected. Cage 1A inhabited by these pests for a period of six months with no indications of wilt; 2A check. Both sets of plants showing healthy vigorous growth.

For more than six months, the plants in these two cages grew with no serious indications of disease. About August 1st, a lot of inferior fruits were collected in a wilt area and placed in cage 4. These fruits were covered with mealy bugs, which I soon noticed ants were carrying over the bridge into cage 1. Microscopic, newly-hatched mealy bugs were also observed migrating by the same route. For convenience, I shall designate the plants in this cage (a), (b), and (c). Plant (c) was showing evident symptoms of wilt by the middle of November. A little later plant (b) was affected, and about December 1st plant (a) began to go with the same trouble. Here we appeared to have a perfect illustration of the way wilt progresses inward from the edge of a field. The check remained in a perfectly healthy condition. Cage 3 showed no wilt, but the roots were mostly rotted, so it was replanted, September 1, 1928, with healthy slips. It appeared desirable to repeat, so this second experiment was discontinued December 20, 1928, as noted above.

Examination of the roots in cage 1, by the Pathological Department gave only *Tricoderma* sp., a saprophytic fungus. None of the fungi, so destructive in the soil of cage 4, were in evidence. Hence, at this stage it was a difficult matter to decide what the casual organisms were, that so quickly resulted in death to the plants in cage 1. Suspicion, however, pointed to the mealy bugs.

For the third trial, I used the same layout, re-sterilizing the soil of cages 1 and 2. These were planted January 12, 1929. By the 30th of March, excellent root systems had developed, so the bridge was replaced connecting cages 1 and 4. By May 20th, mealy bugs were abundant in cage 1, coming from the diseased fruits in cage 4—ants constantly crawling back and forth over the bridge. The primary roots of plant (c), in cage 1, began rotting July 6th, and by August 19th they were all dead; the top showing advanced symptoms of wilt. At this time the roots of plant (b) were also failing and the top beginning to wilt. Plant (a) had a few dead roots, but its top retained a healthy, vigorous appearance.

Isolations from the roots made by the Pathological Department again gave only a sterile fungus and *Tricoderma* sp.—no evidence of parasitic fungi.

By September 9th, plant (a) also showed an advanced stage of wilt and all its roots were dead. The plants in the check developed normally except that some of the roots had collapsed from time to time. This experiment was terminated September 15th, 1929.

The plants in cage 3 were now over a year old, having been planted September 1st, 1928. Although their roots when examined through the glass, appeared in bad condition due to the accumulated pests in the soil,

there was no sign of wilt. The leaves were dark green and healthy, in spite of the fact that myriads of ants were in the soil and these had continuously maintained colonies of mealy bugs in the leaf axils.

The evidence now seemed conclusive that wilt of the plants in cage 1 was caused by organisms, and that these had come over the bridge from cage 4. Mealy bugs had been under suspicion for some time. Yet, as noted above, the healthy plant of cage 3 had been harboring both ants and mealy bugs for more than a year. The possible explanation was that the pests in cage 1, as we know, were from wilt pineapple plants. Those entering cage 3, came directly from the ground, where pineapple mealy bugs were observed on various grasses.

Early in May 1929, I received a letter from Professor Doctor von L. Reh of the Zoological Museum, Hamburg, Germany, requesting information upon pineapple wilt. He stated that the question had been put up to him by a pineapple company in Hawaii. He did not consider that ants could directly cause wilt but suggested that they might carry spores of fungi to wounds in the plant made by other animals. Continuing he says, "Can the mealy bugs alone cause wilt?"

This latter question being right in line with the results that appeared to be developing, I at once decided to increase the experimental procedure and collect all possible field evidence.

A fourth experiment of the same kind was started on May 9th, 1929. The soil of two additional cages was thoroughly sterilized. These I shall designate as cage 1A and 2A. I noted on June 24, 1929 that cage 4 had completely dried out so that all the ants had left. To attract them again from the ground, several over-ripe pineapple fruits were put into the cage and the soil sprinkled well with water. These fruits, I wish to note, were from a field where no wilt was in evidence, yet they were white with mealy bug infestation.

The plants in cages 1A and 2A had developed good healthy roots by June 24, 1929, so a bridge was placed that the ants and mealy bugs could come across from cage 4 into cage 1A. Cage 2A was kept free from insects for a check as in former experiments. I found that mealy bugs and ants were well established in cage 1A by July 2, 1929. The plants in both this and the check cage, however, continued to thrive, the tops having big broad, succulent leaves and only very minor root troubles. At the time of writing, February 15, 1930, there was no sign of wilt in either cage, and yet the plants were more than nine months old. See Plate 35. It is interesting, also, to note that there was none of the chlorophyll spotting which is usually characteristic of leaves that have been fed upon by wilt infected mealy bugs.

It will be recalled in this connection that in the third experiment reviewed above, wilt occurred in approximately three months after ants and mealy bugs were permitted to come in from the wilt area—cage 4. On the other hand, plants in cage 3, for more than fifteen months, maintained excellent color with not a sign of wilt, and yet they had had an abundance of both mealy bugs and ants from the time they were planted, but from a non-wilt source. Hence, my hypothesis appeared proven. And, moreover, an examination of the roots in cage 3 gave nothing to build a hope upon. Practically all the pests of our worst field soils had had a hand in their destruction. Yet the plants were able to keep a good appearance above ground, probably maintaining themselves by the roots in their leaf axils.

In order to test the relation of mealy bugs to wilt on a more extensive scale, another line of experiments was begun May 23, 1929. Twelve of the large root cages were prepared with soil sterilized as before. They were also isolated as in the former experiments, to prevent crawling insects from entering them. The planting material, too, was carefully treated to free it as far as possible of both insects and fungi.

The cages were set up in pairs, one infected with mealy bugs collected from wilting pineapple plants, the other kept clean for a check. From the above, it will be noted that there were six pairs of these cages. Remarkable results were obtained from this experiment. Without exception, wilt developed in each of the cages inoculated with infected mealy bugs. Furthermore, none of the checks developed the disease, the plants maintaining their dark-green color. The data dealing with the history of all twelve cages used in this experiment has been prepared in tabulated form to make it more comprehensive. See Table 1.

From the above table, it will be seen that the disease progresses rather slowly, a period of approximately three months being required for it to make itself evident by the yellowing of the outer leaves. The peculiar spotting of the chlorophyll, however, developed very soon after the infected mealy bugs were placed in the plants. This indicator developed without exception. Check plants, on the other hand, did not have these spots.

To cross-check these results, I decided to see if I could bring about wilt in the large plants of cage 3. These plants, it will be recalled, were about fifteen months old, and had maintained the dark green color indicative of perfect health, in spite of the fact that they had been constantly infested with both ants and mealy bugs. November 27, 1929, two of the three plants were infected with mealy bugs from a wilting field plant. Sixteen days later the characteristic spots appeared on the central leaves

TABLE 1. SHOWING COMPLETE DATA FOR THE SIX CAGES TREATED WITH WILT-INFECTED MEALY BUGS AND SIX CHECKS. PLANTING MATERIAL USED WAS PINEAPPLE SUCKERS. FIGURES IN BRACKETS INDICATE NUMBERS OF MEALY BUGS PUT INTO EACH PLANT. FIGURES IN PARENTHESIS DENOTE POSITION OF PLANTS IN CAGE; *i.e.*, (1) AT LEFT, (2) IN MIDDLE, AND (3) AT RIGHT END, FACING CAGE

Cages	Date Planted	Date Roots Grown	Date Mealy Bugs Put in	Date Root Collapse First Observed	Date Wilt First Observed	Incubation Period (First Wilt)	Remarks
No. 1	5/23/29	6/18/29	6/12/29 [50] 7/26/29 [20]	6/20/29 (2+3) 9/ 3/29 (3) only laterals	9/12/29 (3) 9/25/29 (1) 11/1/29 (2)	3 months	In shade, all plants wilted.
No. 4	5/23/29	6/18/29	6/29/29 [80]	8/20/29 (2+3)	9/3/29 (3) 10/20/29 (1)	2 months 24 days	Two plants wilted, new roots.
No. 5	6/10/29	6/29/29	7/9/29 [50] 7/26/29 [30]	8/20/29 (1)	9/24/29 (1) 10/20/29 (2) 1/20/30 (3)	2 months 15 days	All plants wilted.
No. 8	6/12/29	6/29/29	7/29/29 [50]	9/24/29 (1, 2+3)	10/12/29 (2) 10/19/29 (3) 10/26/29 (1)	2 months 23 days	All plants wilted.
No. 9	5/23/29	6/18/29	6/12/29 [14] 6/12/29 [26] 7/26/29 [50]	8/21/29 (3)	9/6/29 (3) 9/24/29 (1)	2 months 24 days	Two plants showing typical wilt. New roots started.
No. 17	6/7/29	6/25/29	6/20/29 [50] 7/26/29 [25]	9/16/29 (3)	9/16/29 (2+3) 1/25/30 (1)	2 months 25 days	All plants wilted.
				Checks			
No. 2	5/23/29	6/18/29		8/20/29 (2) only laterals			Good growth. No wilt.
No. 3	6/14/29	7/5/29		8/20/29 (2+3)			(2) all roots collapsed. No wilt—new root.
No. 6	6/10/29	7/7/29		9/24/29			No wilt
No. 7	6/12/29	7/5/29					No wilt
No. 10	5/23/29	6/17/29		9/20/29 (1) only lateral			No wilt
No. 18	6/7/29	6/25/29					No wilt

of the treated plants, and after a further period of five days, spots began to appear on the adjoining third plant of the cage. Hence, I had evidence that the infected bugs had moved over in that time. February 20, 1930, the first of the infected plants began to wilt. The leaves of the second plant also developed the characteristic symptoms, March 10, 1930. It will be noted that these old plants followed very much the same schedule after infection, that I had gotten in previous experiments. Here the first plant went down in two months and twenty-three days, and the second in three months and thirteen days. With younger plants the time averaged around three months. See Table No. 1.

At the same time I set up a series of experiments with water cultures. Pineapple plants grow well and produce excellent roots in water. I wanted to see if I could produce the characteristic wilt of the leaves by mealy bug infection under such conditions.

The water for 24 jars was boiled with steam for 10 minutes. A similar number of pineapple tops were fumigated with carbon bisulphide for 24 hours, to free them from all pests. As a further precaution, all the plants were sprayed with an oil emulsion, November 19, 1929, to rid them of any chance mealy bugs. At this time the roots were well developed. Plants Nos. 1 to 12 were used as a check; Nos. 13 to 24 were to be infested with mealy bugs. These two sets were placed on separate tables and every precaution used to keep out all crawling insects.

The latter set was infested with mealy bugs from a wilt-section, November 27, 1929. The supply for plants Nos. 13 to 18 was picked from old pineapple stumps, that had been thrown out of the field. The mealy bugs for the others, Nos. 19 to 24, were taken directly from wilt plants in the field. The characteristic green spots developed on the leaves, 12 to 14 days after the mealy bugs were applied. All the check plants remained normal, both as to top and roots. The history of the twelve infected plants has been prepared in tabulated form for more convenient reference. See Table 2.

The indication here is that wilt-infected mealy bugs carry over from one crop to the next on old, discarded stumps, even though they are carted out of the field. There is this suggestion. however, from the evidence of plants Nos. 13, 15, 17 and 18, that the new generation of mealy bugs, holding over on these dry stumps, may have lost some of their virulence.

It is very interesting to note the character of the roots in these experiments. This is a point that I wished to demonstrate, that the roots die after the leaves cease to function. The evidence here is rather conclusive that the disease from the leaves gradually spreads to the roots, resulting in their collapse.

TABLE 2. HISTORY OF INFECTED PLANTS IN WATER CULTURES

Plant No.	Date mealy bugs put in	Date spots appeared	Period days	Date 1st sign of wilt	Date complete wilt	Period days	Remarks
13	11-27-29	12-19-29	22	None			3-20-30 roots O. K.
14	11-27-29	12- 9-29	12	2-8-30	2-24-30	73-89	2-24-30 some root collapse.
15	11-27-29	None	—	——	——	——	3-20-30 good roots.
16	11-27-29	12-19-29	22	2-10-30	2-24-30	75-89	2-24-30 roots good.
17	11-27-29	None	—	——	——	——	3-20-30 good roots.
18	11-27-29	12-16-29	19	None	——	——	3-14-30 plant green, good roots.
19	11-27-29	12-11-29	14	2-27-30	3-12-30	92-105	3-14-30 roots dead.
20	11-27-29	12- 9-29	12	None	——	——	3-14-30 roots O. K.
21	11-27-29	12- 9-29	12	None	——	——	3-14-30 roots O. K.
22	11-27-29	12- 9-29	12	2-24-30	3-13-30	89-106	3-13-30 roots O. K.
23	11-27-29	12- 9-29	12	3- 8-30	3-19-30	101-112	3-19-30 roots O. K.
24	11-27-29	12-11-29	14	3- 8-30	3-19-30	101-112	3-19-30 roots O. K.

Plants Nos. 13 to 18 were infected with mealy bugs picked from old stumps that had been thrown out of a wilt field. The infection material for plants Nos. 19 to 24 was taken directly from wilting field plants.

During these infection studies we found that the mealy bugs did not thrive when kept free from ants. After two or three weeks they gradually disappeared, in spite of the fact that we had used them in considerable numbers—50 or more per plant. On the other hand, where the ants had free access to the plants, as in cage 3, the mealy bugs soon became very prolific. The interrelation here is interesting and important. Ants are the protectors of the mealy bugs. They guard them in every possible way, even covering them with bits of trash, to ward off their mortal enemies, the lady bird beetles, etc. At least two species of these beetles were frequently observed on our isolated plants, accounting for the disappearance of the mealy bugs. Hence the indications are, that without the ants, natural enemies already present in our pineapple fields, might be able to hold the mealy bugs in check.

UNINFECTED MEALY BUGS DO NOT CAUSE WILT. The evidence from cage 1A goes to show that mealy bugs do not bring about the characteristic chlorophyll spots on pineapple leaves unless they have first fed

upon wilting plants. Moreover, none of the later symptoms of the disease developed. See Plate 35. Cage 3, also, corroborated this evidence.

FIELD OBSERVATIONS ON WILT. In every country where wilt has been studied it has been considered a root trouble. Hence, this was naturally the case during the early investigations in Hawaii. Here this disease appears to increase with an accumulated effect in most of the older areas, wiping out much of the profit. Worse, however, further loss is frequently entailed by the apparent necessity of throwing great fields out of cultivation over extended periods to rejuvenate by planting to grass or other green crops. In some instances large areas have been abandoned entirely.

By our study of the soil and the various organisms affecting the roots of pineapples, a tremendous amount of data has been accumulated. We found that this crop is frequently hampered materially by numerous pests, etc., below ground. In extreme cases, these may destroy most of the feeding roots, slowing up growth. Yet, we know that the pineapple, which indeed belongs to a group of air plants, can maintain itself and flourish with scarcely any roots in the soil, if given favorable climatic conditions. I ask then the question, why should this pruning of, even many of the roots by soil organisms bring about such quick death of the tops? Wilt certainly has more the appearance of a disease.

Every field man has observed how wilt creeps slowly into the sides of his choicest areas. It usually comes in especially along the edges that border old wilt patches, or along the margins of weedy gulches, stone piles, etc. In these latter situations we can often discover dumps of old wilt plants, stumps and other refuse from plant failures. By none of our studies of the problem from the standpoint of soil organisms, however, extending over a period of several years, have we been able to learn what it is that moves into the fields. If on the other hand, we accept the hypothesis that mealy bugs transmit a disease, the known facts fit together perfectly.

CONTROL OF MEALY BUGS. Let me review the situation as I now see it in our field practice with suggestions looking to the alleviation of the trouble:

1. In the preparation of an old area for replanting, say one that has failed because of wilt, every effort is usually made to first turn under the old plants. The stumps are slow to decay in the soil. Even after several green crops and fallowing for a period of about two years, it is an easy matter to find living stumps. Almost universally these old stumps harbor mealy bugs. I find that these pests also carry over on grass roots. This goes to show how persistent they are. Hence, it is easy for them to

wait through our long periods of preparation and start the trouble all over again, in new fields. Many times I have had my attention called to the failure of young plants. The roots of these are often found to be near semi-decayed stumps in the soil. Therefore, I consider thorough preparation of a field the most effective means of eliminating mealy bug wilt. Every old stump and all grass roots must be decomposed or removed from the field and burned to eliminate the trouble.

2. In selecting material for planting, spots are frequently seen on the leaves. Usually such infected plants go in with the others. If any attention at all is given to them, it is thought that they will soon outgrow the trouble. Many of the early failures of young fields may be attributed to this lack of careful selection. Plants having the characteristic circular green spots, evidently have inherited the disease from infected parents. Therefore, I would emphasize that discarding spotted plants before stripping is far more economical than removing wilts from the field several months later.

3. In young fields there is normally a certain percentage of the plants that fail to establish themselves due to so-called early wilt, etc. The failures are pulled out, dumped at the edges, onto stone piles, or anywhere that will most easily dispose of this rubbish. I consider this practice accounts for most of the trouble that we call edge wilt. The infected mealy bugs soon get back into the field where they gradually spread the trouble from plant to plant. The suggestion is then that we should maintain clean culture along all borders, burning stumps and other rubbish. Briefly then, the important cultural considerations as I see the matter at present are:

1. *Thorough preparation of field, eliminating hold over stumps, grass roots*, etc.
2. *Select plants free from spotting.*
3. *Keep borders of fields clean.*

Recognizing that wilt evidently spreads inward from the edges of fields, some of the most observing among the Hawaiian pineapple growers have used various means designed to hinder progress of crawling insects. One of the most useful checks they found is the clean border, frequently cultivated to maintain a dust mulch. To be very effective, however, it had to be of considerable width, but this takes up too much valuable ground. Packing by rain also greatly lessened its efficiency. Another barrier used by several is the so-called ant fence. Its maintenance required considerable expense. In spite of these efforts, however, wilt progressed.

Some light upon the lack of success of these barriers has developed

from laboratory experiments. Mealy bugs, especially when young, move about freely and travel far. On the leaves, I found they progress at the rate of about two inches in a minute. Hence, it would be possible for them to travel the distance of ten feet in an hour. Over soil, however, their progress is greatly retarded due to the irregular surface. Another observation is that young mealy bugs are able to pass rather freely over surfaces coated with the various oils that have been used to exclude ants. This fact was developed from a study of our large root cages. I was able to exclude ants, but I found that it was necessary to treat the standards of the cages almost daily to keep mealy bugs out. Some mornings hundreds of the very minute bugs were seen walking right over the oiled surface of the standards and into the root cages.

I have experimented with ways and means of exterminating mealy bugs by the use of chemicals. This can be done satisfactorily I find, where we have to deal only with those in the leaf axils. I have gotten excellent results from the use of oil emulsions, filling the heart of the plant. This pest also occurs at times on the stem and roots under the soil. Where we have to combat these, a further difficulty arises. No practical method is now known of doing this after planting. I have experimented with stronger chemicals, but the outlook for success is not very promising.

By far the most effective control of pineapple mealy bug I have outlined above as cultural methods. Good farming practice goes far toward keeping these pests in check. If the fields are started clean, with attention to maintaining clean borders the problem is greatly reduced. But as I have already indicated, ants are an important consideration. They undoubtedly are a serious check upon lady bird beetles and other well-known predators of mealy bugs. It may be worth while, therefore, to start a campaign of poisons in our fields. This has proved effective in California orange orchards, against the troublesome Argentine ant. With the Pheidole, however, the bait will have to be different. This ant is not attracted to the standardized California preparation. I have this problem under experiment.

Permanent checking of the mealy bug pest can only be brought about by the further introduction of natural enemies, particularly parasites. These are available in the native home of the pineapple family—subtropical portions of the Americas. A perfect clean-up of the mealy bug, *Pseudococcus nipae* (Maskell), that used to be such a pest on avacados in Hawaii, was accomplished in this way. To succeed in this kind of control, however, requires a tremendous amount of painstaking search, and considerable hardship for the investigator. Yet the results are well worthwhile, and they will pay tremendous dividends to the industry.

INJURY TO VARIETIES OF EGGPLANT BY THE POTATO LEAFHOPPER, *EMPOASCA FABAE* (HARRIS)

By F. W. Poos, *U. S. Bureau of Entomology*, and C. M. Haenseler, *New Jersey Agricultural Experiment Station*

Abstract

Disease like symptoms on certain varieties of eggplant are described which were experimentally produced by *Empoasca fabae* (Harris). Susceptibility of varieties, based largely on observations in New Jersey, is discussed.

In discussing the potato leafhopper, *Empoasca fabae* (Harris), as a bean pest in Ohio during 1926 and 1927, DeLong[1] was perhaps the first to report injury to eggplant by this species when he stated: "The vegetable grower is familiar with the common hopperburn of potato which normally causes the drying, browning, and curling of the edges of the leaves and the consequent dying of the plant. This same type of injury occurs upon eggplant . . . ." Haenseler reported injury to eggplant by leafhoppers in the Plant Disease Reporter Supplement 68, May 1, 1929, as follows: "Hopperburn, leafhoppers. New Jersey severe on Long Purple Variety." The full report was not published and subsequent observations seem to make it advisable to describe in more detail the symptoms of the injury to eggplant caused by *E. fabae*. The production of these symptoms, which has been shown for the first time by experiment to be caused by this leafhopper, is also here reported. The importance of having experimental proof when making detailed descriptions of diseaselike injuries to plants, which are caused by insects, can not be over emphasized.

A marginal burning and curling of the leaves of certain varieties of eggplant (Plate 36) had been observed in New Jersey for a number of years, but not until 1928 did it become apparent that this injury was due to leafhoppers. It was then noted for the first time that leafhoppers were present in abundance on the eggplants which showed severe marginal leaf burning, and occurred in much smaller numbers on several varieties which showed no such injury. During the past two years an opportunity was afforded for making a more careful study of the symptoms and progress of the leafhopper injury, and for observing the relative susceptibility of a number of varieties and species of eggplant which were being grown in Verticillium wilt test-plots at the New Jersey Experiment Station.

The first symptoms of the leafhopper injury on the eggplant may be observed on the younger leaves, which show either an upward or a down-

[1]Ohio Veg. Growers' Assoc. Proc., 13 (1928) pp. 76–82.

Plate 36

Injury to eggplant (Sen Nari variety) by *Empoasca fabae* (Harris). Plant at right confined with adult leafhoppers. Check plant at left. This injury developed within a few days and is characteristic of the beginning of concentrated feeding on egg-plant by this insect.

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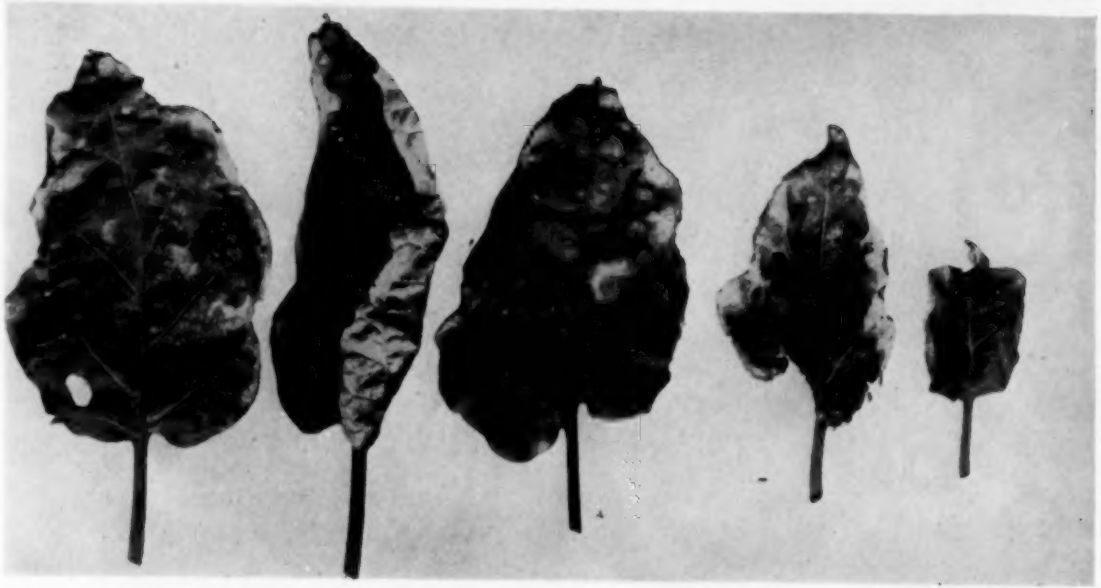

Leaves of eggplant, Long Purple variety, showing more advanced stages of injury caused by *Empoasca fabae* (Harris).

ward cupping due to the retardation of normal development at the leaf margin. The inner portions of the leaf may continue an uneven growth, resulting in a more or less undulate, distorted or puckered surface. Later the margin of the leaf becomes a lighter green or even yellowish for one-fourth to one-third the distance to the midrib. This yellowish margin may be fairly uniform in width or there may be several sectors, usually sharply limited by larger veins, which extend much farther toward the center of the leaf. (Plate 37.) At a late stage the extreme margin of the leaf usually dies, causing further cupping and irregularity of the injured leaf. If the necrotic margin increases to one-fourth or one-half inch in width or involves several of the yellowish, deep sectors, the leaf may become very ragged in outline as a result of cracking and breaking off of the dried portions. The inner portions of the leaf usually remain green, but several large yellowish blotches may occur between the larger veins. The leaf as a whole rarely dies, although its effective surface may be reduced sufficiently to retard appreciably the development of the plant and fruit.

The Long Purple, also known as Italian Long Purple and French Long Purple, is the only variety used commercially in New Jersey which seems to be subject to serious leafhopper injury. The other common varieties, Black Beauty, New York Improved, and Florida High Bush, are only slightly affected. The Japanese varieties Yama Nasu and Sen Nari seemed to be injured to about the same extent as Long Purple. Among the other varieties and species of eggplant grown on the test plots mentioned above, three deserve special mention as being unusually susceptible. These are as follows:

1. *Solanum melongena* F. H. B. No. 75063, from Peking, China, an erect bush growing 18 to 24 inches high with green stems and leaves and with white cylindrical fruit 7 inches long by 4 inches in diameter, yellow when ripe. This variety was more severely injured than commercial Long Purple.

2. *Solanum melongena* variety *viridi* F. H. B. No. 75266, from Buitenzorg, Java, an upright bush 12 to 18 inches high with pale green stems and leaves, white flowers, and a seedy, rather dry, berry-like, white fruit 1½ inches in diameter, ripening yellow. Extremely susceptible.

3. *Solanum onigerum* F. H. B. No. 7454, semi-erect, 12 to 14 inches high with green stems and leaves, white flowers, and an egg-shaped white fruit, 3 inches long by 2 inches in diameter, ripening yellow. Extremely susceptible.

Out of the 30 or 40 different strains, varieties, and related species of *Solanum melongena* which were under observation in New Jersey during

1929 and 1930, those mentioned above were the most susceptible, although many other types proved to be slightly injured. At Arlington Experiment Farm (P. O. Rosslyn, Virginia) among the varietal plantings of the late F. J. Pritchard, the New York Improved variety appeared to be one of the least susceptible to this injury and the Japanese varieties Sen Nari and Yama Nasu were among those most susceptible. Susceptibility to leafhopper attack could not be correlated definitely with any morphological characteristics, although thick, hairy-leaved types seemed to be less subject to injury than the thin-leaved, relatively smooth varieties. Pigmentation has apparently little effect on susceptibility, since both purple-leaved and green-leaved varieties fall in the same group.

Late in September, 1930, a shipment of living *Empoasca* upon a complete plant of *Solanum melongena* var. *veridi* was made from New Brunswick, New Jersey, to Arlington Experiment Farm. This stock of leafhoppers was kept alive in cages for the purpose of showing by experiment that the diseaselike symptoms as described above were actually caused by *E. fabae*, and also to ascertain definitely the identity of this insect. A number of individuals from this material were identified as *E. fabae* (Harris) after an examination of the male genitalia was made. Identifications were made in accordance with a recent revision of this genus by DeLong.[2]

A number of tests were made upon plants of the Sen Nari, Yama Nasu, and New York Improved varieties. Typical injury appeared in the cages which contained *Empoasca* in from two to six days, in the greenhouse, during December and January, with temperatures closely approximating 80 degrees F., while similarly caged plants without the insects remained in a normal condition. This stock of *Empoasca* also developed readily on Whippoorwill cowpea and caused severe injury to this host plant. Under similar cage conditions three adults of *E. fabae*, which were taken from a stock which has been kept developing continuously since 1928 in the greenhouse, were confined upon one eggplant leaf of the Japanese variety Yama Nasu, and within two days the leaf curled and began to wilt. Another test with 12 individuals from this same stock of material, which were confined in a cage upon the Sen Nari variety, showed similar injury within 6 days. These tests under cage conditions prove experimentally that *Empoasca fabae* (Harris) causes serious injury to certain varieties of eggplant, giving symptoms which coincide with those described above as occurring under field conditions in New Jersey.

[2]Tech. Bul. No. 231, U. S. Dept. Agr., Jan. 1931.

NOTES ON THE LIFE HISTORY OF *CHAITOPHORUS POPULELLA* G. & P. (APHIDIDAE, HOMOPTERA)

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ABSTRACT

Chaitophorus populella G. and P. was described as a new species in 1928. Very few biological notes were included with that paper. The unusual abundance, which makes it a pest at Laramie, Wyoming, has increased a desire for knowledge regarding its life history. Observations on its life history are presented below.

Chaitophorus populella was described by Gillette and Palmer (1928) from specimens collected at Fort Collins and Delta, Colorado. A collection of this species was sent to Dr. Gillette for determination from

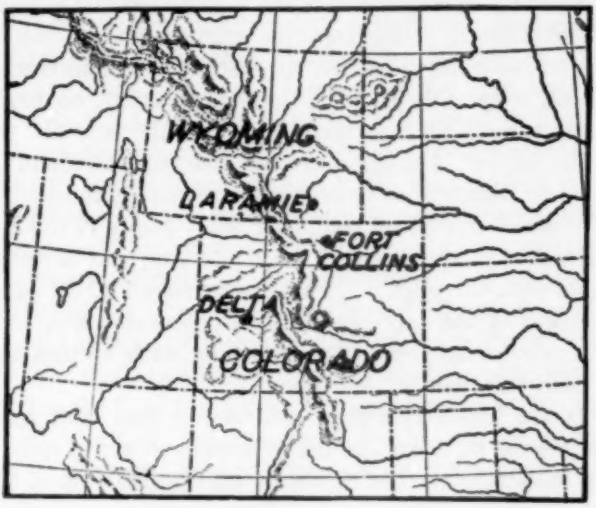

Figure 59.—The known distribution of *Chaitophorus populella* G. and P.

Laramie, Wyoming while the above paper was in press, but were not forwarded in time for the record to be included in that paper. This insect was extremely abundant at Laramie on *Populus* species and occasionally abundant on *Salix* species during the years 1927 to 1930 inclusive, when the observations were discontinued. The aphid was not found on *Populus tremuloides* Michx., a very common species in the mountains about ten miles distant on the windward side of Laramie. The senior writer was unable to find it at Casper in 1927, 1928, and 1929, while the junior writer was unable to locate the species at Wheatland, Wyoming in 1929 and 1930.

The present known distribution of *C. populella* is shown in Figure 59. The fact that it is found on both the east and west slopes of the Rocky Mountains indicates a wider distribution than is shown. The altitude of the three localities ranges between 5000 and 7300 feet.

The aphids were so numerous at Laramie from 1927–30 that the falling honey-dew became rather disagreeable to pedestrians. The sidewalks and vegetation under the infested trees were coated with this excreta after the aphids became numerous, which served as an attraction for flies and other insects.

During the winter months a search was made for the eggs of the pest on trees that had been heavily infested the previous summer. Enormous numbers of eggs were found in the crevices of the rough bark and around scars and injuries, especially where the sap exuded and flowed down the trunks. Therefore on young trees the eggs are laid on the main trunk only, while on the older trees they are laid on the main trunk and older branches, but frequently so high that they cannot be found without climbing the trees. No eggs were found on the smooth, young twigs that bear the leaves. The eggs may be placed compactly in the crevices to a depth of an eighth of an inch or more on heavily infested trees which have only a small amount of rough surface. Many of the aphids crawl into these places in the fall and die; thus the dead carcasses may be intermingled with the eggs. The eggs were found on all surfaces of the trees regardless of the exposure, but no observations have been made during the oviposition period to determine what factors might be influencing their behavior at this time.

The eggs are lemon-yellow in color when first laid, but gradually darken until some of them become yellowish-brown in color by spring, depending somewhat on the exposure, and perhaps upon the development of the embryos.

Several attempts were made in the winter of 1928 and 1929 to incubate and hatch the eggs under artificial conditions, without success. New lots of eggs were placed in the laboratory environments every four to six weeks beginning in November and lasting until March. The eggs were exposed to the following sets of constant temperature and relative humidity conditions:

Temperature ° C.	Relative humidity Percentage
22	40–60–90
27	32–60–72–79–85–93
32	32–70–90
37	40–75–90

Varied temperature and moisture conditions were obtained by transferring the eggs from one set of environments to another in the morning and evening. Conditions available for alternation at one time were (1) 27° C. with humidities of 32, 60, 72, 79, and 90 per cent, (2) 27° C. with humidities of 60 and 85 per cent and 32° C. with humidities of 32, 70, 90 per cent, and (3) 22° C. with humidities of 40, 60, and 90 per cent, and 37° C. with humidities of 40, 75, and 90 per cent. No eggs hatched in either the varied or constant environments. Constant conditions with humidities of 32 and 40 per cent in all temperatures and the 37° temperatures produced drying and shriveling of the eggs in a few days.

The junior writer made careful observations in the spring of 1930 at the time the eggs were hatching and of the behavior of the newly emerged aphids. Beginning about May 1, eggs were collected every few days and observed in the laboratory as well as on the trees. The first eggs hatched on May 18, being found in the laboratory and the field about the same time. A large majority of the eggs hatched during the next four days. Only one lot of eggs hatched in the laboratory between May 1 and 22, when these observations were discontinued. The laboratory relative humidity was lower than in field conditions at this season of the year. Apparently only the eggs hatched that were exposed to the sap exuding from the wounds in the bark of the trees, but this cannot be considered conclusive at present. The newly hatched nymphs remained near the place of emergence for a week or more before migrating to the leaves. The young aphids apparently fed upon the sap of the trees that was abundant in the crevices about the wounds in the trunk. During the time the aphids remained in the place of emergence they were quite active, moving about freely, though seeming in no haste to leave the moist areas. They varied from olive green to light green in color.

The leaf buds of the trees were just beginning to split when the first eggs hatched, indicating a possible relationship between the flow of sap and hatching. The nymphs migrated to the leaves shortly after the new leaves were fully expanded. Trees banded with tree tanglefoot proved that ants, which were very numerous on the trees, had nothing to do with transportation of the nymphs to the leaves, as the aphids reached the leaves as soon on banded as on unbanded trees. At no time were the ants observed to give any attention to the young nymphs on the trunks of the trees although the ants were climbing the trees and were very active. The nymphs remained on the trunks until well developed, after which they migrated to the leaves, apparently through their own efforts, although actual migrations were not observed.

Shortly after the stem-mothers settled on the leaves, the second generation nymphs appeared. In the latter part of June and early July, alate forms appeared. These migrants scattered to various species of *Populus* and *Salix* in the vicinity, apparently not being attracted to a secondary host. The junior writer collected some aphids from wild currant bushes that resembled *C. populella*, but these were lost along with other preserved material that was accumulated during the progress of the observations. The migrants could be found during the remainder of the summer on previously infested as well as newly infested trees. Apparently the migrants were all viviparous as no eggs were found that could be associated with them.

Small, black apterous males had been observed in August and September during previous seasons, but no records were obtained of the date of their first appearance. During these months both apterous males and females, as well as alate females, were present on the same trees.

Several species of Coccinellidae were seen feeding on the eggs and nymphs on the trunks of the trees in the early spring.

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SUGGESTIONS ON MAINTAINING CULTURES OF MOSQUITO LARVAE THROUGH THE WINTER

By LEON C. GLOVER, *Research Assistant in Entomology, University of New Hampshire, Experiment Station*

ABSTRACT

A description of the equipment used in maintaining a culture of mosquitoes (*Culex pipiens* Linn.) throughout the year, together with some ecological and life history observations.

In studying the surface activity and toxicity of certain substances, mosquito larvae make an excellent living organism to work with. This is especially true with substances which are highly surface active in very dilute concentrations and less so in higher concentrations. When using mosquito larvae in liquids various factors, such as temperature, humidity, and equal dosage, which is exact and simultaneous, may be more readily controlled.

Some work of this nature was planned and it was desirable to have mosquito larvae during the winter months. Very little data was avail-

able as to methods of rearing larvae artificially in large numbers, so an attempt was made to devise a suitable breeding pool for this purpose.

Two adjacent concrete bins, each 29½ inches by 30 inches, and 20½ inches deep, were constructed in the insectary. In one the concrete was waterproofed with a standard substance and a drain was installed in the bottom with an overflow pipe leading from the drain to the desired water level. The bottom was then covered with about three inches of muck from an outdoor mosquito breeding pool and staves from an old cider barrel, which had been boiled in water, were weighted to the bottom with pieces of granite. The pool was then filled and the water allowed to stagnate. The other bin of the same size was prepared by adding loam until the bin was nearly full, then turfed with sod from a nearby pasture and two white pines and a cedar, each about three feet high, set out in it. A cage was then constructed, covering both bins, which measured 34 inches wide, 37 inches high and 5 feet 7 inches long. It was covered with 16 mesh copper screening. A door 16 inches by 18½ inches was built in the side of the cage in front of the pool.

Mosquito larvae of *Culex pipiens* were added to the pool in early October 1929. The larvae and pupae did not develop properly when the water became too stagnant, so twice during the winter the water was drained from the pool and the mud removed and replaced by fresh material. When the water became too stagnant some of the full grown larvae and many pupae would become greenish in color and later die. Sometimes these greenish pupae would live and adults emerge. Some plant growth in the pool may retard extreme stagnation.

Fresh fruit was placed in the cage at irregular intervals. This was either apple, usually McIntosh, or grapes. Both male and female adults fed on the fresh fruit throughout the winter. Through October and November no breeding took place, indicating that the fruit was not sufficient food for the production of eggs. Accordingly, a pair of white rats were placed in the mosquito cage. The adult females could not be induced to bite the rats. Finally, the author used himself as a food animal with immediate success. Eggs were deposited from 4 to 6 days after feeding, and hatched in from 2 to 4 days, depending, in part at least, upon the water temperature. No egg deposition was noted unless females had previously fed on blood.

This work is being continued. Adult females may bite one night and if not filled return and bite at some other time. To date it has been unnecessary to introduce new mosquito stock. At the present time the walls of the breeding pool are covered with plant growth (algae) and there are two water plants growing from the bottom. The water has

not been changed since May. Very little breeding took place during the summer months.

Larvae were ready for use in from ten days to two weeks after hatching. Thus, from the time of feeding to the time when larvae are ready to use, varies from three to four weeks and may be longer if the larval food supply becomes depleted. For this reason it is well to rear surplus larvae in smaller containers, thus saving food material in the breeding pool for the breeding stock. Also, larvae reared in this manner are more easily handled.

Marcovitch, (Tenn. Agr. Exp. Sta. Bul. 139, 1928) has published a method for feeding growing larvae on dried blood. Some larvae were reared according to his recommendations. Development was more rapid due in part to higher temperature of the water and possibly in part to the food supply. Larvae for use in any one experiment should be reared under similar conditions, otherwise their resistance may vary.

With humidities above 50% and temperature from 80°F to 95°F. adults are usually active and bite freely. They stay away from the water, resting on the grass, trees, or screening of the cage. With lower humidities the adults move about very little and light on, or near, the surface of the water. This is true also with very high temperatures. Temperature and humidity varied a great deal in the insectary. Temperature ranged from 60°F to 100°F, with an average of about 80°F. Humidity ranged from 10% to 90%, being below 50% a great deal. When the mosquitoes were fed the humidity was brought up to about 80%.

THE USE OF TRANSPARENT CELLULOSE FILMS IN LIFE HISTORY STUDIES

By STANLEY F. BAILEY, *Assistant in Entomology, University of California*

ABSTRACT

Cellophane, a transparent cellulose film, of a permeable nature appears to be very adaptable to the life history study of insects on their host plants. The chief disadvantage in its use out-of-doors is that, when wet, Cellophane becomes flabby and upon drying out has a tendency to crack. Some tests were made to determine the actual conditions of temperature and humidity within Cellophane cages. The results show that the atmospheric temperature and humidity with their hourly fluctuations are rather closely approximated—much more so in the case of temperature than humidity.

During the past few years the manufacture and uses of regenerated cellulose films have increased considerably. Transparent cellulose films,

better known under the trade name of "Cellophane," have been used since their introduction chiefly as wrappers for cigars, candy, fruit, *et cetera*. In addition to the moisture-proof grade used for these purposes a plain transparent grade is manufactured which is permeable to moisture and therefore applicable to life history work. Smith (Journ. Ec. Ent., **22:** 705. 1929) was the first to report the use of "Cellophane" in life history studies of insects. The manufacturing process and the properties of "Cellophane" were given by Hyden (Indus. Engin. Chem. **21:** 405. 1929).

The principal properties of "Cellophane" which make it of value in life history work are its transparency, its permeability to water vapor, and the close approximation to outside temperatures that is maintained within a cage of this material. In addition to its being transparent to ordinary light Pfund (Johns-Hopkins Hospital, Bull. **40:** 228. 1927) investigated the optical properties of "Cellophane" and found it to be transparent to ultra-violet light, allowing approximately 70 per cent of the shortest light waves to pass thru. Also, "Cellophane" is readily permeable to water vapor and to some water-soluble gases as ammonia and carbon dioxide. Hyden (1929) wrote that "This characteristic permits the use of Cellophane as a semi-permeable membrane for the separation of gases from a mixture." Also, "Cellophane may be used as membranes for ultra-filters, permitting the separation of molecules of widely different dimensions, In dialysis work a regenerated cellulose film has been found adaptable for certain liquids where there is not excessive acidity or alkalinity."

There are, however, certain disadvantages in the use of this material, particularly as cages in confining insects on their host plants in the open. When wet, "Cellophane" becomes flabby and has a tendency to collapse, then, upon drying out, or even in a hot, dry wind, to become quite brittle and is very apt to crack. The pliability is imparted to "Cellophane" in the manufacture by a "glycerinating" process and no doubt the successive wetting and drying of cages in the open results in the loss of this glycerin content causing the cellulose film to become brittle. Some difficulty was also experienced in obtaining a satisfactory cement which would tightly seal the "Cellophane" and, in addition, be waterproof. There is now available however from the Du Pont Cellophane Company moisture-proof "Cellophane" adhesive No. 406 which is very satisfactory.

Cages were made after the manner described by Smith (1929) and also by stretching the "Cellophane" over wooden frames or the open end of glass tubes. Whenever there was a moderate circulation of air without

there was no condensation of moisture resulting from transpiration within the cage. On the whole, this material has proven to be very satisfactory in life history studies of thrips, aphids, cicadas, and leafhoppers. "Cellophane" can be had in various thicknesses varying from that of No. 300 which is approximately 0.00088 inches to that of No. 2400 which is approximately 0.0068 inches. The most satisfactory grades were found to be Nos. 300 and 600, the No. 600 is slightly heavier and is somewhat more serviceable.

TABLE 1. HOURLY FLUCTUATION OF TEMPERATURE

Time	Temperature (degrees Centigrade)						
	Atmosphere	Glass Tube	dif.	Cellophane No. 300	dif.	Cellophane No. 600	dif.
7 a. m.	17.0	18.5	+1.5	18.0	+1.0	18.0	+1.0
8	22.0	22.0	0.0	22.5	+0.5	22.5	+0.5
9	24.5	25.0	+0.5	25.0	+0.5	25.0	+0.5
10	27.5	29.5	+2.0	28.5	+1.0	28.5	+1.0
11	30.5	33.5	+3.0	31.5	+1.0	32.0	+1.5
12	34.0	36.5	+2.5	35.0	+1.0	35.5	+1.5
1 p. m.	34.5	38.0	+3.5	37.0	+2.5	37.0	+2.5
2	36.5	38.0	+1.5	38.0	+1.5	39.0	+2.5
3	36.0	40.5	+3.5	38.5	+1.5	38.5	+1.5
4	36.0	39.0	+3.0	39.0	+3.0	40.5	+4.5
5	34.5	40.0	+5.5	37.0	+2.5	38.0	+3.5
6	31.0	32.5	+1.5	32.0	+1.0	32.0	+1.0
Average difference			+2.3		+1.4		+1.8

TABLE 2. HOURLY FLUCTUATION OF RELATIVE HUMIDITY

Time	Per cent Relative Humidity				
	Atmosphere	Cellophane No. 300	dif.	Cellophane No. 600	dif.
7 a. m.	56.5	53.5	— 3.0	57.0	+ 0.5
8	47.0	48.0	+ 1.0	51.0	+ 4.0
9	40.0	40.5	+ 0.5	43.5	+ 3.5
10	35.0	27.5	— 7.5	28.0	— 7.0
11	30.0	20.5	— 9.5	23.0	— 7.0
12	23.0	14.0	— 9.0	16.5	— 6.5
1 p. m.	24.0	14.0	—10.0	11.5	—12.5
2	23.0	14.0	— 9.0	8.5	—14.5
3	27.0	11.0	—16.0	9.0	—18.0
4	27.0	11.0	—16.0	9.0	—18.0
5	33.0	15.5	—17.5	13.5	—19.5
6	39.0	22.5	—16.5	16.5	—22.5
7	52.0	39.0	—13.0	39.0	—13.0
Average Difference			— 9.6		—11.1

Some tests were made to determine the actual conditions of temperature and humidity within such cages and how nearly they approximate the hourly fluctuations without. In determining the relative humidity, precision hygrometers, previously calibrated, were sealed inside "Cellophane" envelopes which were hung up in a pear tree. The temperature records were made from thermometers sealed in "Cello-

phane" envelopes. Also, since glass cages are sometimes employed in life history studies a thermometer was enclosed in a glass tube one inch in diameter and plugged with cotton. The "Cellophane" envelopes and the glass tube were suspended in the tree. Two grades of "Cellophane" were used, No. 300 which is approximately 0.00088 inches thick and No. 600 which is approximately 0.0017 inches thick. The atmospheric readings of both temperature and humidity were taken from a hygrothermograph.

The results show that a slightly higher temperature obtains inside such cages than outside and that the hourly fluctuations in the atmospheric temperature are closely approximated. There is no marked difference in the temperature readings from the cages made of the two different grades of "Cellophane." About 4 p.m. the cages were in the full sunlight and thus the rise in the temperatures within; the air within the No. 600 grade appeared to heat up somewhat more than the No. 300 and cool off a bit more slowly. These data do not show as great a difference between the atmospheric temperature and that within the cage as was obtained by Smith. Further, the results of these tests show that the relative humidity within the "Cellophane" envelope lags behind that of the atmosphere in its fluctuations and that the relative humidity within the cage is much lower than without. This would indicate that the "Cellophane" is rather slowly permeable to atmospheric moisture and that the No. 600 grade reacts less rapidly than the No. 300 to hourly fluctuations in the water content of the air outside.

The above tests show that the actual conditions of atmospheric temperature and humidity and their hourly fluctuations are rather closely approximated within such "Cellophane" cages—much more so in the case of temperature than humidity. On the whole, "Cellophane" of the plain transparent grade seems to be quite adaptable to the life history study of insects on their host plants.

STANDARDIZED OIL SPRAYS

By NEELY TURNER, *Crop Protection Institute*

ABSTRACT

This paper suggests that viscosity, volatility and unsulfonatable residue determinations be published in papers giving results of tests of oil sprays.

Lubricating oils first came into use in 1906 for dormant sprays against the San José scale. Since that time they have been in constant use for dormant sprays, and during the past few years have been developed as

summer sprays. A study of the literature published since the original work of Jarvis (1) and Penny (2) shows hundreds of references to the use of oil sprays. However, any attempt to correlate and summarize this large amount of information results in disappointment and confusion. This seems to be due largely to the lack of standardization in the oil used, method of emulsification and method of application. Penny and Jarvis simply recommended "paraffine" oil, a lubricating oil, as a basis for their sprays. Since their recommendation was found confusing in that the term covered a very wide range of oils, later publications included more specific terms. At first the Baumé test for specific gravity was used, and later viscosity, volatility and other physical tests were specified. The use of oils was greatly increased by the outbreak of the San José scale in the middle west in 1920, and the appearance of the European red mite in eastern orchards the same year. The largest extension in use has come since the work of Gray and deOng (3) which showed that highly refined oils were less toxic to foliage than ordinary lubricating oils.

One of the chief difficulties in correlating results of different workers has been indefinite statements regarding the oil used. Sanders (4) called attention to the indefinite term "red engine oil" and the possible variation in purchasing oil under such a name. The American Association of Economic Entomologists, Committee on Policy, reported (5, 6, 7) on oil emulsions in an effort to correlate the information obtained. This committee gave a definite statement as to the effective range of oils, giving viscosity, volatility and specific gravity. DeOng has published several papers on specifications for oil sprays, the latest of which (8) discusses color, sulfur content, distillation, acidity, volatility, viscosity, oxidation and unsulfonatable residue. Browne (9) has given further information on evaporation and distillation.

It is obvious that it is impossible to standardize procedure and correlate results of tests unless the qualities of the oil used are known. It is also obvious that the fundamental questions concerning the effects of oil on plants and insects cannot be answered without a more thorough knowledge of the chemistry of petroleum. At present there is little published information on the chemistry and refining of petroleum, particularly the lubricating oil fractions. However, the author believes that the information already published is sufficiently complete that fruitful work can be done. The information concerning exact effects of various oils on plants and insects is also meagre. Much work remains to be done, and it is highly necessary that workers using oil sprays include sufficient information in their publications to allow comparisons to be made.

It does not seem necessary to review in detail deOng's (8) statements regarding specifications for oil sprays. His discussion summarizes the information on summer sprays particularly. However, certain suggestions regarding the use of common specifications seem logical.

VISCOSITY: California investigators use the terms thin, medium and thick or light, medium and heavy, referring to viscosity. The light oils are from 50 to 65 seconds viscosity (Saybolt at 100° F) medium oils 65 to 85 seconds and heavy oils 85 seconds up (110 seconds is usually the upper limit). This classification is meaningless when dormant oil sprays for eastern use are considered. These dormant oils range in viscosity from 35 seconds to 375 seconds (oil from proprietary spray mixtures). (10) Moreover, Ginsburg (11) used summer oils of from 160 to 320 seconds viscosity. On account of these variations in use it is logical to suggest that the Saybolt viscosity at 100° F be used in scientific publications rather than the variable terms light, medium, etc.

UNSULFONATABLE RESIDUE: This test is standardized and the Association of Official Agricultural Chemists method should be used. Small variations in results of this test are apparently not significant in toxicity tests on insects.

VOLATILITY: There is no method for measuring volatility of spray oils given by the Association of Official Agricultural Chemists. The California State Department of Agriculture recently published (12) a method which is as follows:

"One gm. of the oil is placed in a 10 cm. flat-bottomed aluminum dish containing 9 gms. of 20–40 mesh sand and the dish heated over an 8 cm. hole on the top of a boiling water bath. Weighings are made up to and including 24 hours and the loss calculated. In making this test it is essential that these conditions be strictly adhered to, otherwise variable results will be obtained."

Although this method is probably not accurate in showing minor differences, it will show whether or not light fractions have been used with heavy to blend for a certain viscosity. It will also show the presence of kerosene or fuel oil. The variation in rate of evaporation of unblended lubricating oils is too small to be significant.

Two of these tests are well standardized and one is of sufficient accuracy for practical purposes. These tests can be made in a majority of experiment station laboratories. It seems to the writer that all scientific papers concerning oil sprays should include at least results of these three determinations on each different kind of oil used. In addition the kind and amount of emulsifier and method of emulsification should be included. If these things are noted comparisons will be much more easily

made and the accumulated information should be of some value. These suggestions apply particularly to materials used in laboratory preparations. When proprietary sprays are used the same information is equally important, but if it is not available the exact name of the material and the date of purchase should be given.

The question has been raised frequently as to whether or not an oil refiner could produce oil identical in characteristics and toxicity over a period of years. In spite of the great variation in crude oils and refinery methods, it is believed that refiners can produce uniform oils, especially highly refined oils, if they have sufficient information as to the characteristics desired. Medicinal mineral oils have been produced under such conditions for many years.

The ultimate solution of all phases of the oil spray problem depends on close cooperation between entomologists, oil chemists and plant physiologists. Oil sprays are exceedingly useful and are of increasing importance, and it is hoped that such cooperation may be obtained.

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A METHOD OF DETERMINING THE RELATIVE TOXICITY OF CONTACT INSECTICIDES, WITH ESPECIAL REFERENCE TO THE ACTION OF NICOTINE AGAINST *APHIS RUMICIS*

By H. H. SHEPARD and C. H. RICHARDSON,[1] *U. S. Bureau of Entomology*

ABSTRACT

A method of determining the relative toxicity of contact insecticides to *Aphis rumicis* L. has been devised that may be used in place of the usual spray tests in cases where greater precision is desirable. Nicotine and nicotine sulphate have been used in developing the method and to serve as standards of comparison of the toxicity of other compounds. Toxicity curves have been determined in two ways for each compound, one in which concentration is variable with time of immersion constant, whereas in the other the time of immersion is variable with concentration constant.

Previous determinations of the toxicity of contact insecticides for the most part have been simple spray tests carried out upon insects on their host plants. Such a method has been described by Richardson and Smith (*1*)[2]. They used *Aphis rumicis* L., the black nasturtium aphid, colonized on nasturtium plants, as a test insect. The plants, bearing numerous aphids, were sprayed with insecticide solutions or emulsions containing sodium fish-oil soap as spreader. The results were recorded after a period of twenty-four hours. Data relating to the toxicity of nicotine, and secured in this manner, are presented in Table 1.

Such a method presents the difficulty that the spreader has more or less toxicity itself. Moreover it is likely to influence toxicity of the test compound by chemical or physical action upon the latter. For example, a 0.3 per cent solution of sodium fish-oil soap has been chosen as the practical minimum concentration which will form a continuous film upon nasturtium leaves infested with *Aphis rumicis*. This spreader solution by itself kills from about 45 to 50 per cent of the aphid population. When this soap is used as a spreader for nicotine sulphate it increases the toxic action of the spray, first, because of its own toxicity and, second, because of the nicotine base which the free alkali of the soap releases from the nicotine sulphate. Such a test therefore can not give a true value for the relative insecticidal activity of nicotine sulphate.

Tattersfield and Morris (*2*) have described in detail an apparatus for determining relative toxicities of contact insecticides. By their method numerous small subsamples of aphids (*Aphis rumicis* L.) on disks of

[1]Resigned from the Bureau of Entomology in June, 1928.

[2]The numbers in italics refer to the literature cited at the end of the paper.

flannel were sprayed under controlled conditions. Only wingless adult females were used in the tests. A disadvantage of the method lies in the necessity for using a spreader in the spray in order to wet the aphids thoroughly with the test material.

TABLE 1. INSECTICIDAL EFFICIENCY OF NICOTINE AND NICOTINE SULPHATE WITH OR WITHOUT A SPREADER, AS DETERMINED BY THE USUAL SPRAY METHOD USING *Aphis rumicis* ON NASTURTIUM PLANTS. UNLESS OTHERWISE NOTED, THREE SPRAYINGS HAVE BEEN AVERAGED IN THE CASE OF EACH CONCENTRATION OF EACH OF THE VARIOUS MATERIALS

Compound	Concentration in grams per 100 cc.	Total Population	Average per cent of kill	Standard deviation[1]
Nicotine:				
without spreader	0.10	987	96.0	1.4
	.05	929	88.9	.3
	.01	1,010	53.2	2.4
with 1 per cent saponin	.10	869	98.8	.1
	.05	1,003	89.6	2.8
	.01	1,048	38.6	1.6
with 0.3 per cent sodium fish-oil soap	.05	292	100.0	—
(one spraying at each of the 0.05 and 0.01 concentrations)	.01	287	98.6	—
	.006	612	93.3	2.9
Nicotine sulphate:				
without spreader	.10	983	92.4	2.2
	.05	961	87.1	2.6
	.01	1,409	49.6	6.3
with 1 per cent saponin	.10	1,458	97.9	.6
	.05	1,338	91.8	1.0
with 0.3 per cent fish-oil soap	.006	1,327	99.5	.3
0.3 per cent sodium fish-oil soap: 19 sprayings	—	6,442	46.0	2.8
1 per cent saponin: 9 sprayings	—	2,566	14.4	2.5

[1]The standard deviation is derived by the formula: $S.D. = \sqrt{\frac{\Sigma d^2}{n-1}}$, where each squared deviation (d^2) is weighted with respect to population.

Time of action of the test compound is a factor which is seriously neglected in the usual spray method. During the twenty-four hour period between application of the spray and determination of the result each individual aphid is more or less thoroughly coated with a dried film of the spray material. If the test compound is particularly toxic the aphids may have received an internal dosage great enough to kill them within a few hours; another compound which is much less toxic may still produce death in less than twenty-four hours. Such a pair of compounds

would be rated by this method as having the same relative toxicity. For example, nicotine and nicotine sulphate both at 0.5 per cent concentration have been tested against *Aphis rumicis* on nasturtium plants, no spreader being used. The results, recorded after different periods, are presented in Table 2. Each period is represented by the average of two or more tests.

TABLE 2. INSECTICIDAL EFFICIENCY OF NICOTINE AND NICOTINE SULPHATE WITHOUT SPREADER AS DETERMINED BY THE USUAL SPRAY METHOD WITH *Aphis rumicis* ON NASTURTIUM PLANTS, THE TIME OF NOTING PERCENTAGE OF KILL BEING VARIED. STANDARD DEVIATIONS CALCULATED AS IN TABLE 1

Time Period	Nicotine			Nicotine sulphate		
	Population	Per cent kill	Standard deviation	Population	Per cent kill	Standard deviation
One hour.....	473	41.2	10.0	786	21.5	4.8
Two hours....	1,065	56.8	7.3	970	10.9	2.8
Four hours....	1,187	64.8	7.2	1,102	50.3	12.3
Six hours.....	1,013	57.4	12.1	616	59.7	5.7
Twenty hours .	149	88.6	—	—	—	—

The results at the end of several hours are the same for both materials. However, nicotine sulphate, under these conditions, requires at least four or five hours to overtake nicotine base in toxic action.

Aphids sprayed while still on the plants are exposed to a variety of conditions which are not easily controlled. Temperature and relative humidity are controllable if the proper room is available; spray tests, however, take up too much room to be handled in sufficient numbers in an ordinary box in which the temperature and humidity can be kept constant. Evaporation of spray liquids from aphid-infested leaves is very uneven, many aphids remaining immersed in the spray much longer than others. Young and old members of the usual aphid colony react differently to toxic materials.

Owing to the rapidity with which tests of new compounds may be made by the spray method, however, it is a very useful means by which to sort out the promising ones for more refined studies. The method has a practical advantage, moreover, in its resemblance to field methods of insecticide application.

EXPERIMENTAL METHODS. In these experiments a method has been attempted in which external conditions have been controlled and the other disadvantages of the spray method have been overcome as much as possible. A grouping of the insect population in numerous subsamples allows more thorough statistical treatment of the resulting data than in the case of the spray method in which a few large subsamples are used.

The effects of nicotine and nicotine sulphate have been studied more than those of most contact insecticides. Nicotine is an effective insecticide for many uses; hence it provides a good standard with which to

compare other contact insecticides, just as lead arsenate is used in comparisons of stomach poisons. For these reasons nicotine and nicotine sulphate are used in this preliminary study. The results will form a standard of comparison for any later studies of this nature. The nicotine sulphate solutions were made by titrating nicotine base with 0.1 N sulphuric acid in the presence of methyl red, the end-point in this case being very close to pH 5.0.

Wingless adult females of *Aphis rumicis* were brushed lightly from nasturtium plants into a large beaker. A considerable supply of individuals thus obtained was brushed on to white paper and groups of ten then separated into medium-sized test-tubes plugged with cotton. In this manner random samples were taken from a fairly uniform population. The tubes of aphids were held in a constant-temperature chamber at 26° Centigrade until they reached that temperature.

Before the nicotine solutions were used they also were brought to about 26° Centigrade. Each test-tube containing the aphids was then filled half full or more with solution, and a fragment of cotton or cheesecloth was adjusted below its surface to prevent the aphids from floating.

In all dilute water solutions of test materials each aphid has a film of air around its body. In some cases all but the limbs of the insect is surrounded by a considerable bubble. There is such an apparent variation in the quantity of air in the surrounding film that one would expect much less reliable results than have been obtained. The use of a spreader to effect a wetting of each aphid has been tried. However, most spreaders are undesirable as they cause the aphids to stick together and their legs to become entangled. Moreover, one of the chief advantages of the new method is the elimination of the complicating effects of spreaders.

The immersion of each group of aphids was timed carefully. An attempt was made to keep the room temperature such that no considerable change would occur during the shorter intervals of exposure to the solutions. Those groups which were exposed for fifteen minutes or more were usually set away in the constant-temperature chamber until their immersion periods were over. After immersion each group of aphids was poured on a porcelain plate and removed from the liquid to a filter paper with a camel's-hair brush, an operation requiring, after some practice, less than thirty seconds. The filter paper having absorbed excess moisture, the aphids were then transferred to a small beaker covered with cheesecloth and set away in the constant-temperature chamber with the temperature held at 26° Centigrade and the relative humidity at 65 to 70 per cent.

It is of interest to note at this point that aphids immersed according to this method in distilled water for one hour are not affected. When a few were immersed for three hours, 40 per cent did not recover, and 75 per cent did not recover from an immersion of four hours. Hence the actual drowning from immersion in insecticide solutions up to one or two hours is rather slight.

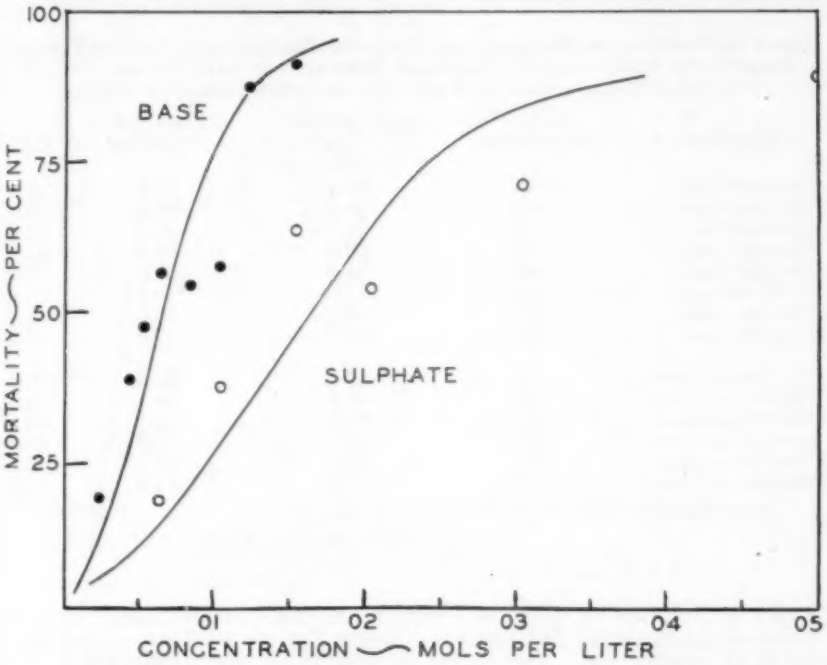

Fig. 60.—The relative toxicity of nicotine and nicotine sulphate to *Aphis rumicis* L., time of application being maintained constant. Each point is derived from the mean kill in 30 groups of ten adult aphids each, results being determined at the end of three hours.

In determining the percentage of kill in each group, the criterion of death was the inability of the aphid to make normal walking movements. It has been observed that most of those individuals that can not walk after a rather short time do not recover from the effects of the insecticide.

In the earlier stages of this study it was desirable to find the best time at which to determine the percentage of kill. A series of groups was observed each hour from two to six hours after removal from the solutions. Since there seemed in a rough way to be little difference in counts

obtained for the same point it was decided to make the counts at three hours. This is a convenient time after each series of experiments for determinations to be made the same day and still gives a period long enough for most of the aphids to dry off and recover if they are going to do so. A second reading of the number killed was made about twenty-four hours after immersion; this set of determinations has been used for comparison with the first.

TABLE 3. TOXICITY OF NICOTINE AND NICOTINE SULPHATE AT VARIOUS CONCENTRATIONS TO *Aphis rumicis* L., IMMERSED THEREIN FOR ONE MINUTE. COUNTS OF PER CENT KILL MADE AT THREE HOURS AFTER IMMERSION PERIOD

Compound	Molar concentration	Mean per cent kill in 30 groups of 10 aphids each	Standard deviation	C.V. [1]
Nicotine base.....	0.002	18.0	16.5	91.6
Nicotine base.....	.004	38.3	21.7	56.5
Nicotine base.....	.005	46.7	22.9	49.2
Nicotine base.....	.006	59.0	26.7	45.3
Nicotine base.....	.008	54.0	20.0	37.0
Nicotine base.....	.010	57.0	19.1	33.6
Nicotine base.....	.012	86.3	15.0	17.3
Nicotine base.....	.015	90.7	12.0	13.3
Nicotine sulphate.	.006	17.7	13.8	78.2
Nicotine sulphate.	.010	36.3	23.1	63.6
Nicotine sulphate.	.015	63.0	43.1	68.4
Nicotine sulphate.	.020	53.3	31.2	58.6
Nicotine sulphate.	.030	70.0	24.8	35.4
Nicotine sulphate.	.050	88.3	12.1	13.7

[1] The coefficient of variation (C. V.) is the following ratio:

$$\text{C. V.} = \frac{\text{Standard deviation} \times 100}{\text{Mean}}$$

TABLE 4. TOXICITY OF 0.002 M NICOTINE AND NICOTINE SULPHATE TO *Aphis rumicis* L., IMMERSED THEREIN FOR VARIOUS PERIODS OF TIME. MEAN PER CENT KILL IN EACH CASE IS FOR 30 GROUPS OF TEN APHIDS EACH

Compound	Immersion time in minutes	3-Hour Counts: Mean per cent kill	3-Hour Counts: Standard deviation	3-Hour Counts: C. V.	24-Hour Counts: Mean per cent kill	24-Hour Counts: Standard deviation	24-Hour Counts: C. V.
Nicotine base....	2	7.0	8.8	125.3	23.7	19.6	82.5
Nicotine base....	4	23.3	14.0	60.0	25.7	16.3	63.5
Nicotine base....	6	40.3	24.0	59.6	36.0	19.8	54.9
Nicotine base....	8	55.3	31.2	56.3	50.7	26.1	51.5
Nicotine base....	10	66.7	22.6	33.9	54.3	21.3	39.1
Nicotine base....	15	87.0	13.9	16.0	74.0	18.7	25.2
Nicotine sulphate	10	10.3	10.3	100.3	28.0	18.1	64.6
Nicotine sulphate	20	17.3	14.4	83.1	29.7	17.9	60.3
Nicotine sulphate	30	24.3	17.6	72.2	32.3	19.4	60.1
Nicotine sulphate	45	37.3	21.8	58.4	42.7	21.6	50.7
Nicotine sulphate	60	43.3	21.4	49.4	51.3	18.0	35.0
Nicotine sulphate	75	41.7	24.9	59.8	51.0	18.8	36.9
Nicotine sulphate	90	60.0	27.8	46.3	59.3	23.8	40.1

A series of thirty groups containing ten aphids each has been found to be sufficient to give a rather reliable determination of each point in a toxicity curve.

EXPERIMENTAL RESULTS. The first series of determinations is given in Table 3. From these data toxicity curves (Figure 60) have been constructed based upon variable concentration of nicotine and nicotine sulphate, the time of immersion (one minute) being maintained constant.

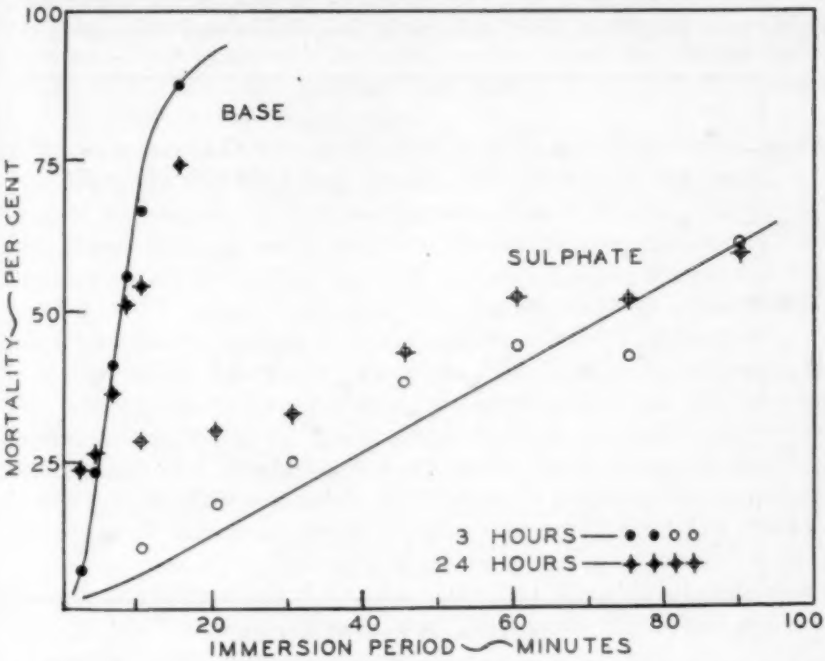

Fig. 61.—The relative toxicity of nicotine and nicotine sulphate to *Aphis rumicis* L., concentration of nicotine (0.002 M) being maintained constant. Each point is derived from the mean kill in 30 groups of ten adult aphids each, results being determined at the end of three and of twenty-four hours on the same groups.

A second series of determinations is given in Table 4, with the corresponding curves in Figure 61. In this series the concentration of nicotine has been kept constant at 0.002 molar, while time of immersion has been the variable.

Two sets of determinations are given for each curve in this series, one from counts of per cent kill at three hours from treatment and the second at twenty-four hours. The two sets of counts show the greatest differences at their upper and lower limits, especially in the case of nicotine

base which acts much more rapidly than does nicotine sulphate. It is obvious that at the lower end of the curve certain weak individuals succumbed after three hours and were recorded as killed when the twenty-four hour counts were made. On the other hand at the upper end of the curve certain individuals were strong enough to recover after the three-hour counts were made and so reduce the twenty-four-hour counts.

It is interesting to note that means in the middle portion of each curve have greater standard deviations than means near the ends of the

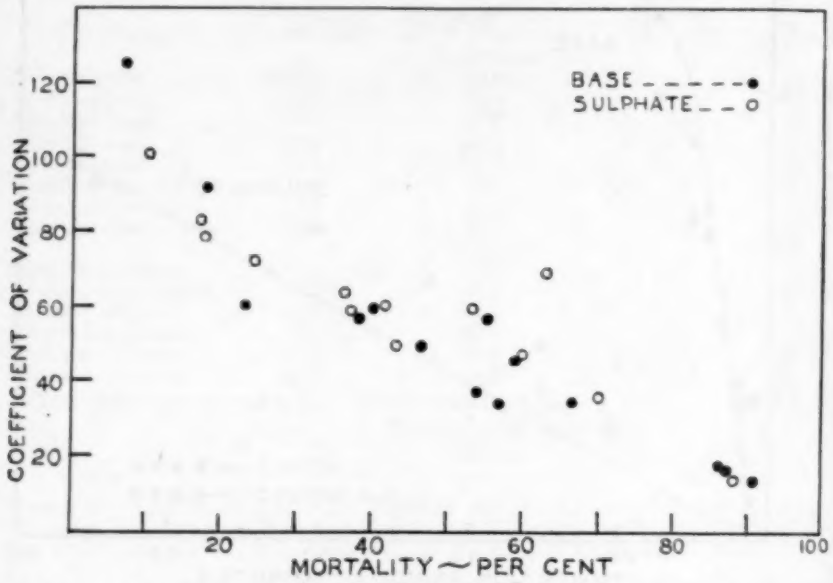

Fig. 62.—The relation of the coefficient of variation to the mean mortality in the data determined after three hours as given in Tables 3 and 4.

curves. This of course follows from the fact that in the case of 50 per cent kill there is possible the maximum "spread" or deviation in individual measurements, whereas the means which approach either zero or 100 per cent are limited in one direction at those points. The set of twenty-four hour counts in Table 4 does not show this regularity very well. The earlier counts seem more reliable. Individual variations in resistance and errors due to variation in external conditions probably have much less effect on results in the shorter period.

The coefficient of variation depends upon a mean which increases with concentration or time and upon a standard deviation which varies

within relatively small limits such as just described; and it is found that it decreases as the mean increases. This is shown in Figure 62 to be close to a straight line relationship.

Such workers as Peters (*3*), Shackell, (*4*, *5*), Shackell *et al* (*6*), and Trevan (*7*) have given descriptions and figures of typical toxicity curves. Trevan (*7*) suggests that the "curve expressing the percentage of mortality, or of some other limiting biological effect, produced by varying doses of a drug on animals of a certain species, shall be called the 'characteristic' for that particular drug, effect and species." Hence the toxicity curves shown in Figure 61 may be termed the characteristics for nicotine and nicotine sulphate used against *Aphis rumicis* L., under the conditions of these experiments.

The relations of the two curves in Figures 60 and 61 are similar, in the first figure the variable being concentration whereas in the second it is time of immersion in a solution of constant concentration. Shackell (*5*) also shows that curves in which concentration is constant and time variable are similar to those in which concentration is variable and time constant. "It seems conclusive that the form of the curve relating dosage to effect is unaffected by the method of measuring dosage."

McGovran (*9*) has recently stated that free nicotine in aqueous solution is more toxic to certain aphids than nicotine sulphate. He used the honeybee (*Apis mellifera*) in a study of interfacial tension between aqueous solutions and the integument of insects. Based upon the results of these experiments was a study of the effect of nicotine solutions conditioned as to interfacial tension upon various aphids. The relative toxicity of nicotine and nicotine sulphate to mosquito larvae has been discussed by the authors in a recent paper (*8*). The present study shows that there is a similar relation between the toxicity of base and sulphate when aphids are treated as described.

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A NEW TYPE OF INSECT CAGE

By FLOYD F. SMITH, *U. S. Bureau of Entomology*

ABSTRACT

A micro-cage, devised for confining leafhoppers and certain other insects to small areas on leaves or stems of plants, and which seems to have certain advantages over other previously described cages, is described.

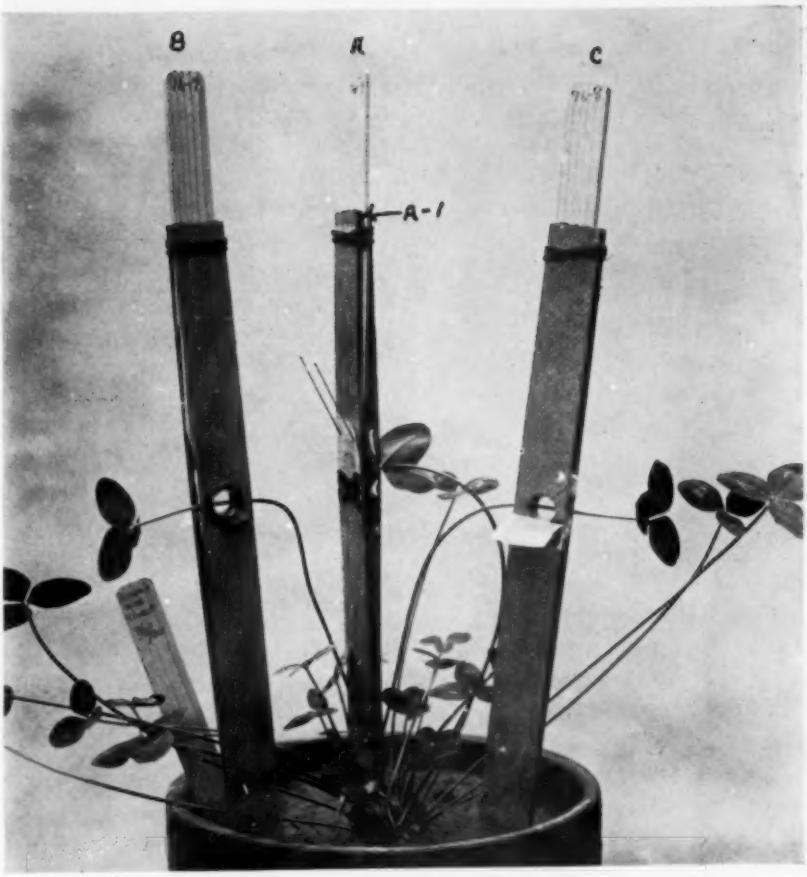
In the study of the life history and the feeding habits of several species of Empoasca[1] the need for a small cage which would serve to confine experimental individuals to definite parts of the host plant became apparent. Newcomer and Yothers[2] used a clip cage for confining mites to apple leaves. Apple foliage is rather firm and sufficiently strong to bear the weight of such a cage. Storey[3] devised a spring-and-tube type of cage which he found useful in confining leafhoppers to definite areas on corn and sugar cane. Such a cage would be useful on alfalfa and clover, plants having small foliage and with weak petioles and stems. However, a cage devised for use on the leaves of such plants (Pl. 38, 1A) together with a modification of it, for use on their stems (Plate 38, 1B and C), which seems to have certain advantages over the types referred to above, has been developed and is herewith described.

A straight-grained white pine board, 12 inches long, three-fourths of an inch thick, and of any convenient width, had a hole seven-sixteenths of an inch in diameter bored through from edge to edge about 4 inches from one end. The board was sawed lengthwise into strips seven-thirty-seconds of an inch in thickness. Using a 16-gage circular saw which cuts a three-thirty-seconds of an inch kerf, each strip was then sawed

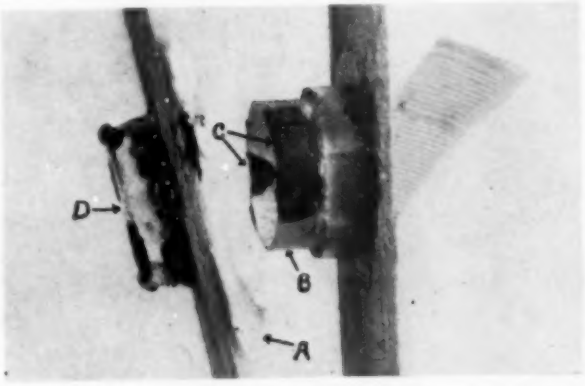
[1]Order Homoptera, Family Cicadellidae.

[2]Newcomer, E. J., and Yothers, M. A. Biology of the European red mite in the Pacific Northwest. U. S. Dept. of Agr. Tech. Bul. 89, pp. 18, 19. 1929.

[3]Storey, H. H. Transmission studies of maize streak disease. Ann. Appl. Biol. 15: 1–25. (pp. 2, 3). 1928.



1. Cage and plant.



2 Cage modified and more enlarged.

A NEW TYPE OF INSECT CAGE.

through the bored portion and for 8 inches of its length. This split the strip into halves each of which was approximately one-sixteenth of an inch in thickness. The lower four inches of the strip was not sawed. These parts when cut at this thickness were found to be more resilient than thicker ones and less fragile than thinner ones. Material for 40 cages was sawed out in one-half hour's time by one man in the carpenter's shop at Arlington Farm.

To the inner side of one-half of the cage over the bored hole was attached a rectangular piece of heavy flannel cloth, such as is used for polishing silver, which served as a buffer for the leaf. To the inner side of the opposite half of the cage and centered over the bored hole was attached a 15 mm. glass micro-ring such as is used for mounting specimens on slides. (Several kinds of glue were used at first for attaching the cell parts to the wood of the cage but moisture from the foliage soon softened the glue and the cages came apart. The use of sealing wax, broken into small pieces and melted into place with a hot needle, was found to be much more satisfactory and cages made up with it were still in good condition after a full season's use in the insectary.) The edge of the free end of the ring had attached to it a narrow circular strip of the flannel cloth which thus presented a resilient surface for contact with the leaf. A rectangular piece of silk bolting cloth was attached to the outside of the cage immediately below the bored hole and arranged so that the free end could be drawn across the opening and held in place by two insect pins. To prevent raveling it was found desirable to select these pieces from the margin of the bolting cloth so that the selvage was on the end used for pinning. To reduce the possibility of splitting the wooden strip and to give greater stability a narrow piece of thin wood was attached across the top end of one-half of the cage. (Pl. 38, 1, A-1.) The two halves of the strip were held together with a rubber band at the top end and the pressure on the leaf was adjusted by inserting one or more thin wooden pot labels between the halves at the top. The unsplit, lower end of the cage was sharpened so that it could be forced into the soil.

A modification of this cage for use on petioles or stems is shown in Plate 38, 2. A hole was cut through the flannel cloth covering the bored hole in one-half of the cage (Plate 38, 2 A) and the edges fastened down smoothly with sealing wax. The cloth on the edge of the micro-ring was removed and a strip of Bristol board, cut to form a snug fitting ring on the inside and of a width to leave a three-eighths inch projection beyond the glass ring, was inserted and fastened in place with sealing wax (Plate 38, 2 B). The projecting edge was notched on opposite sides for

receiving the plant petiole or stem. In order to prevent the escape of the insects past smaller petioles, a narrow strip of the flannel cloth was attached across each notch (Plate 38 2, C) on the outside of the Bristol board, which was resilient and was adjusted with tweezers to close the notches. To the outside of the opposite half of the cage was attached another micro-ring and its open end closed by attaching a circular cover glass (Plate 38 2, D). This was an aid in permitting light to reach the interior of the cell and served as a chamber for the leafhopper which facilitated the transfer to other plants without removing it from the cage.

In using either type of cage the plant part was placed in the desired position in the cell, the leafhopper, if a small nymph, was then introduced into the cell by means of a camel's-hair brush, and, if a large nymph or adult, by means of a short length of 4 mm. glass tube. A gentle puff of air from the mouth through the tube forced the insect, without injury, out of the tube and into the cage. The bolting cloth flap was then pinned over the opening to close the cell. When a fresh area on the same leaf was to be moved into an exposed position in the cell, the tension of the cage was reduced by slightly forcing apart the two halves and the leaf was pulled through in the desired direction without opening the cell and removing the leafhopper. Certain species of Empoasca were reared through the nymphal stage in these cages as successfully as on plants in large cages. Aphids and whiteflies have also been reared successfully when confined in these cages.

The advantages of this type of cage seem to be:

1. Isolation of individual insects for detailed records on biology. The insects were reared in these cages without apparent interference with their normal activity.

2. Localization of feeding of the insect. The insect may be confined to definite small areas on the stem or either surface of the leaf. The histological and symptomatic studies of the plant parts fed upon are thus facilitated.

3. Self-support. No weight of the cage need be borne by the plant.

4. Ease of manipulation and adjustment of pressure on the plant parts.

5. Compactness. Sixteen cages have been used at one time on a plant in a single 8-inch pot.

6. Small cost and ease of construction.

Scientific Notes

Some Fungous and Bacterial Diseases of Pecan Weevil Larvae. Considerable difficulty has been experienced in rearing the pecan weevil (*Curculio caryae* Horn) to the adult stage. This was due to the high mortality of larvae after they had entered the soil for the resting period. It was found that about 95 per cent of the larvae had died of various diseases.

Several organisms were isolated from the diseased larvae and four have proved to be parasitic upon this insect. Of these, the most important were two fungi, which were identified by Vera K. Charles of the U. S. Bureau of Plant Industry as *Metarrhizium anisopliae* (Metch.) Sorok. and *Sporotrichum bassiana* Bals.; *M. anisopliae* also has been found to be parasitic upon the larvae of the green June bug (*Cotinus nitida* Linne), and *S. bassiana* upon the larvae of the larger corn stalk borer (*Diatraea zeacolella* Dyar).

Preliminary tests with these two fungi under controlled conditions have given from 75 to 100 per cent kill of pecan weevil larvae. More extensive field tests are in progress to determine the effectiveness of these diseases as a control measure for this insect.

Two undetermined species of parasitic bacteria are also under investigation.

H. S. SWINGLE and J. L. SEAL, *Alamaba Experiment Station, Auburn, Alabama*

The Northern Fowl Mite. The Northern Fowl Mite (*Liponyssus sylviarum* C. & F.) has lately been reported in the Province of Quebec, although observations point to the fact that it has been here for some time. According to Mr. Arthur Gibson, Dominion Entomologist, there are only two previous Canadian records, from British Columbia and Ontario.

It is interesting to note that this pest has been taken locally on the following wild birds: Starling (*Sternus vulgaris*), Purple Martin (*Progne subis*), Kingbird (*Tyrannus tyrannus*), English Sparrow (*Passer domesticus*), American Robin (*Planesticus migratorius*) and Catbird (*Galeoscoptes carolinensis*).

On some fowls examined by Dr. R. L. Conklin, Veterinarian, Macdonald College, extensive scabby areas were found on the body, some as much as two inches in diameter. These were attributed in the first place, to the feeding of the mites, followed by a secondary pus infection accentuated by the weakened condition of the birds. The flesh was apparently unaffected.

Determination was made by Dr. H. E. Ewing, U. S. National Museum, Washington, D. C.

W. E. WHITEHEAD

The maple bladder gall, *Phyllocoptes quadripes* Shim., is somewhat common on soft maple and occasionally so abundant that groups of leaves, especially on small trees, may be badly deformed as a result of numerous reddish bladder galls some eighth of an inch in diameter developing over most of the leaf surface. Ordinarily this mite is not injurious, and attracts notice simply because of the somewhat conspicuous, brightly colored leaf deformation. A general infestation in Lenox, Mass., by this mite was brought to our attention in June, and in this case there was evidently economic damage. The infested soft maples had a trunk diameter of nine or ten inches. The foliage was pale and somewhat thin, and the trees were evidently

not very thrifty. Two of these were so badly infested that comparatively few normally functioning leaves remained. Most of the others, especially those on the lower branches, were simply masses of galls and evidently unable to function with a reasonable degree of normality. Earlier work has demonstrated that this mite can be readily controlled by dormant applications of a lime sulfur spray.

E. P. FELT

Skunks as Grasshopper Destroyers. For several years past, the writer has been interested in the food of fur-bearing mammals. As the skunk is one of the commonest and most frequently taken of these mammals, more stomach analyses of this species have been made than that of any other species. Most of the skunks have been taken by trappers, during the open season, from Nov. 10th until Feb. 15th. The specimens examined are all from the vicinity of Ithaca, N. Y.

Of 230 skunk stomachs examined, 103 have contained remains of *Melanoplus femur-rubrum*, or 43 per cent of the animals examined. Of those containing grasshoppers, the contents of the stomach, computed in percentage by bulk, had from 15 per cent to 100 per cent of these insects. Skunks taken in January and February, while not so numerous as those taken earlier in the season, likewise contained grasshopper remains. As these remains were fairly well comminuted, an accurate number of the insects taken by a skunk at a single feeding cannot be readily computed, but the contents of one stomach yielded nearly half a pint. The grasshoppers taken in the winter months are probably picked from the grass, where an early frost had killed them, or possibly dug from the ground or straw stacks where they pass the winter in a dormant stage. In the late summer it seems not improbable that many more would be eaten.

Surprisingly few arthropods were found other than grasshoppers. A millipede had been eaten by one, several sowbugs by another, while a third had the remains of a carabid in its gut.

W. J. HAMILTON, JR., *Cornell University, Ithaca, N. Y.*

Demonstration of the Practical Value of Cold-Mixed Petroleum Oil Emsulsions. Several years ago, modifications of a method for making cold-mixed lubricating oil emulsions were suggested,[1] and sufficient experience in the large-scale production of an emulsion by one of the proposed formulas was gained to indicate that the product had considerable practical value. The formula requires petroleum oil and potassium fish oil soap in about the same proportions used in the so-called government formula for the boiled emulsion. The oil is thoroughly and not too rapidly mixed in the semi-liquid soap, the final product being a paste which resembles mayonnaise in physical appearance and contains about 89 per cent of oil by volume. The paste is very stable and may be mixed at once with water for spraying purposes or stored almost indefinitely in tight containers. Any petroleum fraction from kerosene to heavy lubricating oil and a variety of soaps, if sufficiently fluid, may be used as the ingredients of this paste. Further details are given in the paper referred to above.[1]

Tests of a preliminary nature with pastes prepared from various soaps and oils showed that an emulsion made with rosin fish oil soap resisted to a large extent the breaking action of hard water. The more recent and extensive work of Siegler and Brown[2] with cold-mixed emulsions made of rosin fish oil soap and lubricating oil, in

[1]Richardson, C. H., and Griffin, E. L. This journal 19, No. 3, 525–529 (1926).

[2]Siegler, E. H., and Brown, L. U. S. Dept. Agric. Mimeographed circular E.-277 3 pp. Mar. 1, 1930.

the proportions indicated above, shows that these preparations are very resistant to the breaking action of the hard waters often encountered in limestone regions. In regions where the water is reasonably soft the ordinary potassium fish oil soap is satisfactory.

Emulsions made by this formula have been employed for a number of years in certain commercial apple orchards in Maryland, and Virginia. As the method is rapid, economical and requires simple equipment,[2] it would seem to merit more extensive use.

C. H. RICHARDSON, *Dept. of Zoology and Entomology, Iowa State College, Ames, Iowa*

Experiments with Japanese Beetle Traps: During the summer of 1930 a letter was received from a member of a firm manufacturing Japanese bettle traps in Philadelphia, in which it was stated that the writer had noticed from casual observation that traps with white baffles were more effective than traps with green baffles. Previous to the receipt of this letter no experiments had been made with traps the different parts of which were of different colors. Following this suggestion, however, experiments were made with five traps all parts of which were painted green in comparison with five traps painted green except for the baffles, which were painted white. All traps were placed under similar conditions and so arranged that an all-green trap was placed within two feet of a trap with white baffles. The traps were set out on July 11, and the experiment was discontinued on August 11. During the period of experimentation the five traps with the white baffles captured 117,825 beetles, whereas the five traps which were entirely green captured, during the same period of time, 84,225 beetles. There was thus a difference of 39.9 per cent in favor of the traps with white baffles.

This interesting result prompted the writers to compare five traps painted all green with five traps having both the baffles and funnels painted white. This experiment was started on July 23 and ended on August 11. During this period the all-green traps captured 21,025 beetles, whereas the trap with white baffles and white funnels captured 44,225 beetles, or a gain of 110.3 per cent. After this experiment a much larger series of traps was set up in the field. Owing to the construction of the trap there were eleven possible combinations or variations of green and white parts. The test was started on August 11 and discontinued on August 14. As this series of traps was under observation only a short period in 1930, the experiment will be repeated during 1931. Results conformed, however, with the results in earlier trials in that white baffles appeared to be more effective than green baffles and white funnels far superior to green funnels. No explanation of these results is definitely apparent at this time. It is the opinion of the writers, however, that the white color prevents the formation of shadows and makes for a lighter entrance.

E. R. VAN LEEUWEN and P. A. VAN DER MEULEN, *U. S. Bureau of Entomology, Moorestown, N. J.*

44th ANNUAL MEETING
AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS
NEW ORLEANS, LOUISIANA, DECEMBER 29-31, 1931

By vote of the Association at the Cleveland meeting, a special committee was appointed by the President to arrange for the program of the next annual meeting. The matter has been under consideration for some time and a plan has been worked out so that the entire meeting of the Association and its Sections will be finished in three days.

The opening session will be held on Tuesday morning, December 29, when business will be conducted and the President's address delivered. In the afternoon three group meetings will be held, one for general papers, one for the Section of Apiculture and another for the Section of Plant Quarantine and Inspection.

On Wednesday morning, December 20, there will be three group meetings, one for general papers, one for the Section of Plant Quarantine and Inspection and another for the Section of Extension. In the afternoon three group meetings will also be held,—the first on general papers, the second on papers relating to insect physiology—and the third on papers relating to insect toxicology.

On Thursday morning, December 31, a joint meeting will be held with the Cotton States Branch. About 45 minutes will be devoted to the reading of papers selected by the officers of the Cotton States Branch and the balance of the session will be given over to four papers on special subjects presented by invitation of the committee. The closing session will be held Thursday afternoon.

No evening programs of the Association will be held. This will make possible the reservation of Tuesday evening for the public address before the Entomological Society of America, and for the Entomologists Dinner which will be held on Wednesday evening.

	Tuesday Dec. 29	Wednesday Dec. 30	Thursday, Dec. 31
A.M.	Opening Session Business President's Address	General Papers Quarantine and Inspection Extension	General meeting with Cotton States Branch. Invitation papers only.
P.M.	General Meeting Apiculture Plant Quarantine and Inspection	Three groups of subject matter General Insect Physiology Insect Toxicology	Closing Business
Eve.	No session	Entomologists Dinner	

This is a somewhat radical change from the arrangement of previous programs and early notice is given in order that members may be informed as to the set-up for the meeting well in advance of the time for submitting titles of papers for the program.

A. F. Burgess, Chairman
W. C. O'Kane
T. J. Headlee
Special Committee on Program

JOURNAL OF ECONOMIC ENTOMOLOGY

OFFICIAL ORGAN AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

AUGUST, 1931

The editors will thankfully receive news matter and other items likely to be of interest to our readers. Papers will be published as far as possible in the order of reception, except that papers of reasonable length may be accepted in the discretion of the editor for early publication at $3.00 per page for all matter in excess of six printed pages, a part page counting as a full page, this limit not including acceptable illustrations. Photo-engravings may be obtained by authors at cost.

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ANNUAL SCIENTIFIC MEETINGS: 1931-1932, New Orleans; 1932-1933, Atlantic City.

Entomologists generally will rejoice in the award of the Capper gold medal for distinguished service to agriculture and the accompanying honorarium of $5000 to Dr. L. O. Howard, late Chief of the Federal Bureau of Entomology, and very recently resigned from the Federal Service. It is a well deserved tribute to a man who has occupied for a half century a leading part in the development of economic entomology. Dr. Howard, in his comments upon the award, calls attention to the fact that this recognition would have been impossible without the cooperation of his loyal and devoted associates, and presumably he would include in this group not only those closely associated in the official work of the Bureau of Entomology, but also the larger group, both in this country and abroad, which has cooperated so effectively in the Federal work. The award is a most gratifying recognition of Dr. Howard's outstanding position as a leader in economic entomology, and it is also, as he himself points out, a compliment to all who have been working industriously on the problems of economic entomology. It is evidence that the practical value of a study of insects, their ways and methods of control has won recognition which we know is amply justified by the progress of the past fifty years. Incidentally, this recognition coming while our beloved leader is still active, is much more gratifying to him, his friends and associates than any posthumous recognition could possibly be. Entomological progress during the period so largely controlled and directed by Dr. Howard by no means closes a chapter of productive effort. It should be construed as laying a foundation for an even fuller appreciation of the economic importance

of insects and as establishing the need for extending economic entomology into comparatively unoccupied fields. This is particularly true in the case of medical entomology, a phase which has keenly interested Dr. Howard for many years. We take this occasion of extending to Dr. Howard our heartiest congratulations upon this well deserved recognition.

Reviews

A Laboratory Guide to the Study of the Wings of Insects, by JAMES CHESTER BRADLEY, pp. 1–41, text-figures 10, Daw, Illston and Company, Ithaca, New York, 1931.

Plates to accompany the above, Nos. 1–67. Price $1.25.

Suggestions for the Instructor in connection with the use of the above. Lithoprinted, pp. 1–17, 2 Figs. Price $.75.

One supplementary sheet of additions and corrections and one supplementary plate of venation (Plate 2a. Diptera).

The 67 plates illustrate the wings of 69 species of insects, belonging to no fewer than 13 orders, those most numerously represented being the Diptera (16) and Hymenoptera (23). The three final plates provide for supplementary interpretations in venation in the Diptera, Lepidoptera and Hymenoptera. The "Guide" fairly teems with information concerning the study of venation, including discussions of the historical development of the subject, the theories of origin of the insectan wing, the veins and their tracheation, and other subjects. Examples of natural and artificial keys are provided and discussed. Particularly useful will be found the comparisons of the various systems of venation most commonly used at the present time (*Diptera*.—Schiner, Comstock–Needham; *Lepidoptera*.—Herrich-Schäffer, Comstock-Needham; *Hymenoptera*.—Cresson, Rohwer-Cushman, MacGillivray-Comstock-Needham, and the Bradley interpretation). The "Suggestions," intended only for the use of instructors, provide supplementary data to guide the teacher in a correct interpretation of certain critical points in a study of the wings.

It should be noted that in the "Guide," Martynov's terms for the primary divisions of Pterygote insects, *Neoptera* and *Paleoptera*, are used, but in the later suggestions and corrections, the prior terms proposed by Crampton, *Neopterygota* and *Archipterygota*, have been added.

Various sets of outline wing-figures intended to insure accuracy and uniformity of presentation by the student have been available in the past, notably the curtailed set offered by the Comstock Publishing Company, and the more elaborate series issued by MacGillivray shortly before his death. The present offering of figures is by far the most detailed and carefully chosen, and, supplemented by the various Guides and Suggestions, will assuredly do much to make the study of wing-venation less difficult and, at the same time, more interesting to the student. Dr. Bradley's unparalled knowledge of the subject is sufficient assurance that the materials presented are not only well chosen from the standpoint of the student but are entirely authoritative and may be relied upon by the specialist in individual orders.

The uses to which this set of wing-figures may be devoted are many, as indicated by the author.—"The study of insect wings is approached from three standpoints: 1,

as a laboratory illustration of phylogenetic series; 2, as an elementary training in research methods of comparative morphology; and, 3, for the purpose of acquainting the student of entomology with the details of the venation for practical use in the identification of insects." In some institutions the guides and figures may well be used as a text for a single course in the study of wing-venation. At the Massachusetts State College it has been found advisable to distribute the rich materials of this study throughout three distinct courses in Systematic Entomology. Various other methods of utilization of this welcome aid to the correct presentation of the subject of insect venation may well come to the mind of individual teachers. It may confidently be predicted that many institutions where entomology is taught will now avail themselves of the services of this new and highly efficient guide to the study of wing-venation.

C. P. ALEXANDER

Blattlausgallen. Histogenetische und biologische Studien an Tetraneura-und Schizoneura gallen, Die Blattlausgallen im Dienste prinzipeller Gallenforschung. F. ZWEIGELT, Berlin, P. Parey. 1931. 648 pages. 155 figs. 5 pls. R. M. 52.

One of the most stimulating books which has appeared in the field of Cecidology is the extensive monograph on aphid galls by F. Zweigelt. He has studied in a most intensive manner the biology, anatomy, histology and development mechanics of galls of *Tetraneura ulmi* and *Schizoneura ulmi* on *Ulmus montana*. The enormous amount of information that is contained in the first 448 pages cannot be analyzed, but some of the general results may be noted briefly.

Plant galls may be conceived as reaction- or protection-tissues. Gall producing or non-gall producing aphids induce growth reactions, which in essence it is impossible to distinguish. The saliva which is introduced into the sucking channel, contains poisons, specific for each species, against which the plant tries to protect itself by formation of cellulose sheets around this channel. These cellulose sheets are formed by active transport of starch from the neighboring cells. At the same time there is almost always a hypertrophy of the cell nuclei in action and this hypertrophy is the lower limit of gall formation. In non-gall producing aphids, many sucking channels are surrounded by necrotic tissues. In gall producing species fewer channels and necrotic changes are found as the plant decomposes the poison. The true galls possess a very restricted nutrition area on the leaf. Its damages remain localized on the Ulmus leaf. The fundatrices very soon lose their motility. Only during their early development phases are they able to suck on non-gall tissue; in the later life they are starving on normal leaf tissue. An increasing specialization on host plants takes place and parallel to the more restricted food possibilities develop highly restricted reactions of the plant tissue.

Becher's theory of the "fremddienlichen Zwechmässigkeit" of galls threatened to busy the biological side of the problem. *Zweigelt* has proven definitely that no such phenomenon exists. There exists a very complicated system of action and reaction between plant and host. Also the opening mechanism of the galls can be readily explained from the development mechanics of the disequilibrated leaf. The dorsal necrose, which induces the opening process is antagonized by a contemporaneous ventral hypertrophy. "The gall does not open because the aphids want to get out, but the aphids come out because the gall is opening."

F. S. BODENHEIMER

Current Notes

Charles Dury, the veteran colopterist, died July 20.

Dr. F. R. Petherbridge, Entomologist of Cambridge, England, visited the Wenatchee, Washington laboratory on May 9 and 11.

Robert H. Nelson was appointed Junior Entomologist, Bureau of Entomology, June 15, to be stationed at Sumner, Wash.

C. H. Clifton has been appointed Agent, at the Bureau of Entomology, Berkeley, California and assigned to investigations of the sugar beet leafhopper.

W. T. McAllister has been appointed Field Assistant, Bureau of Entomology, and assigned to investigations of the oriental fruit moth parasites at Moorestown, N. J.

Mr. G. Beall has been appointed temporary Junior Entomologist, Entomological Branch, at the Chatham, Ont. laboratory for a period of six months dating from May 15.

Mr. Allen M. Pierson, a recent graduate of the Alabama Polytechnic Institute, has accepted a graduate assistantship at Iowa State College, Department of Zoology-Entomology.

Dr. H. H. Darby, Mrs. Darby, and Dr. E. W. Emmart, of the Bureau of Entomology, Mexican fruit worm laboratory at Mexico City, resigned effective June 30.

R. A. Fisher has been appointed Field Assistant, Bureau of Entomology at the Parma, Idaho sublaboratory and C. W. Schaefer, Field Assistant of the Madison, Wis. field laboratory.

The Bureau of Entomology laboratory for the investigation of insects affecting stored tobacco was moved June 30 from Danville, Va., to 200 Bland Street, Richmond, Va.

A. W. Morrill, Jr., Bureau of Entomology, was transferred June 30 from the Dried Fruit Insect Investigations at Fresno, Calif. to the Stored Tobacco Insect Investigations at Richmond, Va.

Dr. D. E. Fink, Entomologist of the Philadelphia, Pa., Bureau of Entomology field laboratory has been transferred to Takoma Park, Md., effective June 30. The Philadelphia laboratory has been discontinued.

C. R. Jones reported on June 16 as temporary Field Assistant, Bureau of Entomology, and is now stationed at Bridgeport, Conn., conducting general life-history investigations of the Japanese beetle.

Messrs. J. W. Matthewman and H. A. Gilbert were appointed temporary Insect Pest Investigators, Entomological Branch, for a period of six months and reported for duty at Ottawa on June 1 and June 17, respectively.

Mr. I. M. Hawley, Senior Entomologist, Bureau of Entomology, formerly located at the Salt Lake City, Utah, field laboratory, has been transferred to the Japanese beetle investigations with headquarters at Moorestown, N. J.

Prof. F. S. Arant, Department of Zoology-Entomology, Alabama Agricultural Experiment Station, returned to duty July 1 after a year's leave of absence for graduate work toward the doctorate at Iowa State College.

C. W. Getzendaner, Junior Entomologist of the Bureau of Entomology, who has been taking post-graduate work in entomology at Iowa State College, Ames, Iowa, returned to his duties at Puyallup, Wash., May 1, 1931.

Athol W. Greene, a graduate of the Virginia Polytechnic Institute, Blacksburg, Va., was appointed temporary Field Assistant, Bureau of Entomology, effective June 15, and assigned to the Tobacco Insect Investigations, at Richmond, Va.

Mr. Paul B. Allen, Jr., who served in 1930 as Field Assistant at the Wenatchee, Washington laboratory was reappointed to that position and resumed his duties on June 5, succeeding Harrold A. Bonnet whose term expired June 17.

Ralph Schopp was appointed Junior Entomologist, Bureau of Entomology, effective May 28, and assigned to duty at Sumner, Wash. Mr. Schopp has had experience in the Bureau, having held a temporary position on corn-borer work in Ohio.

G. J. Haeussler,, Bureau of Entomology, has recently transferred his laboratory from Antibes to Nice (Alps-Maritimes), France. His new location brings him closer to the main sources of parasites in the orchards of southern France and northwestern Italy.

J. K. Holloway and H. J. Willard, of the Moorestown, N. J. Bureau of Entomology field laboratory, received on May 26, from the Steamship Augustus at New York, the first consignment of oriental fruit moth parasites to be shipped from Europe this year.

Dr. W. V. Balduf, of the department of entomology, University of Illinois, accepted a three month appointment as Field Assistant and will assist in studies of the biology of *Empoasca* spp. in the insectary at the Arlington Experiment Farm, Va.

The Seventh National Shade Tree Conference meets at the Boyce-Thompson Institute for Plant Research, Yonkers, N. Y., August 27 and 28 and at the Bartlett Tree Research Laboratories, Stamford, Conn., August 29.

Mr. R. Glendenning, Entomological Branch, reports that the Vancouver, B. C. City Council has authorized a continuance of the control campaign against the European earwig, the cost of which for 1931 is estimated at $25,000. Control work involves the distribution of poison bait.

The Belleville, Ontario, Canadian Entomological laboratory has made several express shipments of the woolly aphis parasite, *Aphelinus,* to the Wenatchee, Wash. laboratory. These iced express shipments have been very successful in carrying the parasites on the 5-day journey across the continent.

On May 1, B. J. Huckenpahler, Field Assistant, Bureau of Entomology reported for duty at Asheville, N. C., where he will assist R. A. St. George in studies of the southern pine beetle. Mr. Huckenpahler received his B.S. degree from the University of Minnesota in March.

Mr. R. Glen of the Saskatoon, Saskatchewan laboratory, Entomological Branch, was notified recently of his appointment to the Caleb-Dorr Fellowship in Agriculture, at the University of Minnesota, 1931-2. Mr. Glen stood second in a group of sixty-one applicants for this Fellowship.

Dr. W. E. Steenburgh, Entomological Branch, completed his post-graduate studies at the University of Toronto in April and has returned to duty at the Belleville, Ont., laboratory. The degree of doctor of philosophy was conferred on Mr. Steenburgh at the spring convocation.

Dr. Floyd F. Smith, Bureau of Entomology was transferred from the Division of Cereal and Forage Insects to the division of Tropical, Subtropical and Ornamental plant insects, on June 8 and appointed as entomologist, for duty at the Tropical Greenhouse in Washington, D. C. He will make a study of the cyclamen mite and other greenhouse insects.

Dr. J. R. Hobbs, of the Harvard University Medical School, was given a temporary appointment as Field Assistant at the gipsy-moth laboratory, Melrose Highlands, Mass., on May 16. Dr. Hobbs will continue investigations on the wilt disease and bacterial diseases of the gipsy moth which he has conducted during the past two summers under temporary appointments.

Dr. F. S. Bodenheimer, authority on citrus insects in Palestine, visited the Lindsay, Calif., office of the Bureau of Entomology, June 30. Dr. Bodenheimer desired to discuss with E. A. McGregor the latest developments in the control of insects with finely divided sulphur dusts. He was accompanied to Lindsay by R. S. Woglum, Entomologist for the California Fruit Growers Exchange. He also visited the Department of Entomology of the University of Arizona at Tucson.

Dr. Alberto Graf Marin, head of Servicio Sanitario Vegetal, of Chile, visited the oriental fruit moth parasite laboratory at Moorestown, N. J., on May 20 to 21. Dr. Marin was particularly interested in the technique of mass rearing of parasites and in the breeding of *Ascogaster carpocapsae*, a parasite of the peach and codling moths not present in Chile.

Messrs. George Hoppin and H. Leach, Entomological Branch are in the Vancouver district, B. C., continuing an investigation on the hemlock looper and black-headed tip moth. They report that the airplane dusting control work carried out in Stanley Park last year was completely effective, very few caterpillars having been found in the park this summer.

R. W. Burrell, Bureau of Entomology, of the Japanese-beetle project, in Australia, reports the finding of oriental fruit moth in moderate numbers at several points in that country, with parasites fairly numerous in the area about Sydney, New South Wales. Four species of parasites have already been recovered by Mr. Burrell, one being *Gambrus stokesii*, a species previously reported from that region.

During the present summer, Mr. R. E. Balch, Entomological Branch of the Fredericton laboratory, N.B., is continuing an investigation on the black-headed tip moth in Cape Breton Island, and will also study the tussock moth infestation on spruce in Nova Scotia, the balsam woolly aphis infestation in Nova Scotia and southern New Brunswick, and the spruce sawfly outbreak in the Gaspe peninsula.

Under the direction of C. E. Hood, of the Bureau of Entomology Gipsy-moth Laboratory, experiments for the control of *Heterocampa guttivitta* Walker were begun in May in western Massachusetts. Serious outbreaks of this lepidopterous pest have occurred in New England at 11-year intervals in areas where sugar maple and beech predominate, and the species began to be noticeably abundant again in 1930.

A. C. Davis, formerly connected with the University of California, and who has been working on the pepper weevil in cooperation with the Santa Ana laboratory, has been given a probational appointment as Assistant Entomologist, Bureau of Entomology, at the Arlington Experiment Farm, Rosslyn, Va. He will conduct studies on mushroom pests. He succeeds O. E. Gahm, who resigned last fall.

On June 19, the headquarters of the Big Bend Plant Quarantine Division was moved from Marfa to Alpine, Tex. As Alpine is more centrally located as a base of operations for the trap plot experiments, Messrs. Cavitt and Tittle, temporary employees of the Bureau of Entomology, also moved their headquarters to Alpine. They will be located at the Plant Quarantine Laboratory.

A small colony of a eulophid, which is apparently a species of Chrysocharis, was liberated in Strong, Me., on May 27. This hymenopterous parasite issued from *Phyllotoma nemorata* Fall. material received at the gipsy-moth laboratory from Austria last winter. *Phyllotoma nemorata* Fall. is a leaf-mining sawfly on birch. It appeared in epidemic form in Maine in 1927 and has since been noted in New Hampshire, Vermont, Massachusetts and New York.

On May 22, Dr. F. C. Craighead, Bureau of Entomology, visited Rainelle, W. Va., in company with Dr. Carl Hartley of the Bureau of Plant Industry and T. W. Skuce, Extension Forester in West Virginia, to investigate the extensive dying of white oak throughout that section of the country. It is believed that the death of these trees is the result of the freeze of May 26 and 27, 1925, which occurred after the foliage had formed.

Dr. T. E. Snyder, Bureau of Entomology, left Washington June 8 to secure a collection of termites from Dr. Alfred Emerson, of the University of Chicago. Dr. Emerson obtained a large collection of termites on his recent visit to European museums and exchanged many specimens for the Bureau of Entomology while on this trip. The present number of named termite species in the National Museum Collection of Isoptera is 795 species, including 565 types of one kind or another.

On June 8, G. R. Struble, Bureau of Entomology, started field work at the California Experiment Station base on the Stanislaus National Forest, Calif. He will be assisted by Albert Wagner. Studies will be centered for the season on the fir engraver beetle, with the object of developing methods of control. The University of California will cooperate on the project through the assignment of Dr. Aaron Gordon, who will carry on experiments to determine the possibility of preventing attacks of the fir engraver by tree-injection methods.

T. E. Bronson, of the Madison, Wis., Bureau of Entomology laboratory, has just completed new rain and wind recorders. These are an improvement over the

machines developed last year, as they record wind directions as well as velocity. Instead of the charts which had to be changed daily, a 90 foot roll or chart is to be used this year which will run for about two months. A section will be removed weekly, however, to prevent it from winding too much on the drum and altering the time.

Satin moth scouting is being conducted both in Nova Scotia and New Brunswick under the direction of the Entomological Branch District Inspectors, and to date a few localized outbreaks have been found in new areas in Nova Scotia. In New Brunswick, no signs of new infestations have been found as yet. In British Columbia the scouting is confined, this year, to the area east of the known infested territory. It is being done by Mr. C. L. B. Brown under the immediate direction of Mr. R. Glendenning of the Agassiz laboratory.

C. E. Hood, Bureau of Entomology of the gipsy moth laboratory, conducted spray experiments during June for the control of the saddled prominent, *Heterocampa guttivitta* Walk. and the elm leaf beetle, *Galerucella luteola* Mull. The caterpillars of the former species at intervals defoliate woodland areas where beech and sugar maple predominate in New England. The control experiments against the elm leaf beetle are intended to ascertain whether a single early spraying with lead arsenate, to which fish oil is added as an adhesive, will protect the foliage throughout the season.

The pale western cutworm outbreak in the Prairie Provinces is completely absorbing the time of the officers of the Lethbridge Entomological Branch laboratory. The control campaign is being carried on under the general supervision of Mr. H. L. Seamans; Messrs. McMillan and Paul of the Saskatoon laboratory are working under Mr. Seamans' direction, from Indian Head and Saskatoon respectively. Mr. Manson is being established at Assiniboia and Mr. Farstad will presently be established at Drumheller. In this way the entire infested area will be canvassed and control brought directly to the greatest possible number of farmers.

C. H. Popenoe, of the Bureau of Entomology, together with Frederick E. Dunham and C. A. Carrello of the Motion Picture Laboratory, left Washington May 4, for Louisiana, where in company with K. L. Cockerham, Entomologist in charge of the sweetpotato weevil laboratory at Biloxi, Miss., and officials of the Louisiana State Department of Agriculture, parts of a motoin picture dealing with the cultural methods required for control of the sweetpotato weevil were obtained. Upon the completion of this film in the fall a two-reel educational motion picture will be available on this subject for the use of agricultural workers and growers.

During June a number of Bureau of Entomology shipments of parasites were received at the gipsy moth laboratory from the Budapest Hungary substation. These consisted of parasites of the European pine shoot moth, *Rhyacionia buoliana* Schiff. secured in Austria; parasites of the gipsy moth from Austria and Hungary and parasites of the brown-tail and satin moths from Hungary. A small colony of adults belonging to the genus *Tranosema* was put out at North Conway, N. H., on June 18. This hymenopterous parasite of *Phyllotoma nemorata* Fall., a leaf-mining sawfly on birch, was received from Austria during the past winter.

C. P. Clausen, Bureau of Entomology, who left Washington last November for the Far East to continue his search for parasites of the citrus black fly, arrived in Havana, Cuba, on June 3 with a shipment of parasites, which will be liberated there. On May 31 Mr. Clausen inspected the infestations in Panama, where colonies of one of the parasites, *Eretmocerus serius* Silv., had been liberated in January, and reports that, whereas at the time of liberation the trees were heavily infested, now citrus is almost entirely free from the black fly. Addiional parasitic material will be sent to Panama from Cuba. Mr. Clausen has been engaged in collecting these parasites in the Far East since the spring of 1929.

On May 15 and 16, J. M. Miller, Entomologist of the Bureau of Entomology, in charge of the western bark beetle laboratory at Palo Alto, Calif., made an investigation of conditions in the yellow pine type of the Sierra National Forest, where some special sample plots were established by the Bureau of Entomology in 1925. It was found that the western pine beetle, which had been in an epidemic status for the past four years, has suddenly increased during the season, 1930, and that large groups of trees within these plots had been attacked. As the winter of 1930-31 has been one of the driest on record, these plots will afford an excellent opportunity to study the effect of moisture deficiency on an increasing infestation of the western pine beetle.

L. G. Baumhofer, Assistant Entomologist, Bureau of Entomology, who for the past three years has been assigned to the study of the injury to pine plantations at Halsey, Nebr., by pine tip moths, arrived at Coeur d'Alene, Idaho, laboratory on April 30. Mr. Baumhofer assisted by F. B. Foley and L. J. Farmer, temporary employees, spent a few weeks on the bark-beetle control projects of Region 4, where he made detailed examinations of the actual results secured from the burning standing method of control. This method consists in spraying an inflammable oil upon the bole of the trees, and then burning. It is only applicable for the treatment of lodgepole pine trees infested by the mountain pine beetle. Mr. Baumhofer returned to Halsey about June 16.

On May 21, Dr. J. M. Swane, Entomological Branch, attended a conference at Hart House, Toronto, of representatives of the Entomolgical Society of Ontario and other interested persons, with Dr. Patterson, Director of the Dominion Meteorological Service, present, to discuss the recording of meteorological data in relation to agriculture, with special reference to entomology and plant pathology. At this conference a committee was appointed with Dr. Swaine as chairman, to approach those interested in the various universities, colleges and experimental stations throughout the Dominion, with a view to securing suggestions as to the additional meteorologcal data desired. The suggestions obtained from these various sources are to be considered by the committee and presented in the form of a report to the Director of the Dominion Meteorolgical Service for his criticism. The final proposals or recommendations are to be presented before the Dominion and provincial Departments of Agriculture and the Dominion Department of the Interior.

H. H. A. Jaynes, Bureau of Entomology, has made what is perhaps the first airplane shipment of beneficial insects from South America to North America. On May 8 he sent by airplane from Turjillo, Peru, 1,075 adults of *Ipobracon rimac*, a

hymenopterous parasite of the sugarcane moth borer. The shipment arrived at Miami, Fla., on May 11, and, in cooperation with E. R. Sasscer, Entomologist in charge of foreign plant quarantines, and J. V. Gist, collaborator with the Plant Quarantine and Control Administration of the State Plant Board of Florida, was then sent by express to New Orleans, arriving there on May 13. Three hundred and twenty-seven of the wasps were alive and in good condition. The total trip was less than six days, whereas by ship and train it would have required about 22 days. The percentage of survival was better by airplane, although the parasites were not kept at low temperatures, as they are when sent in the ordinary way.

On June 20, Prof. R. W. Harned was appointed Principal Entomologist, Bureau of Entomology and placed in charge of the Division of Cotton Insects. The appointment of Professor Harned fills the vacancy in the Cotton Insect Division caused by the separation of B. R. Coad from the service last February. During the past few months F. C. Bishopp, in charge of the Division of Insects Affecting Man and Animals has been acting in charge of the cotton insect work and has carried on this important detail very satisfactorily. The appointment of Professor Harned will relieve Mr. Bishopp of this double duty and will enable him to devote all his attention to his own important and rapidly expanding field. In order to become thoroughly familiar with the work which is now being done on cotton insects, Professor Harned will spend considerable time in the field with temporary headquarters at Tallulah, La. Later on his headquarters will be transferred to Washington, D. C.

On June 30, after 53 years of service in the Bureau of Entomology, Dr. L. O. Howard retired from active duty. It is needless at this time to record Dr. Howard's outstanding services, which have long been known to all Entomologists. A statement referring briefly to the more important features was published in the Official Record for July 4, 1931. His active interests in entomological work will not cease with his retirement, and he will continue to be associated with the Department as a collaborator. For half a century Dr. Howard has taken a very prominent part in entomological affairs throughout the world. Dr. C. L. Marlatt says of him: "for 33 years Dr. Howard was Chief of the Bureau and during this period was the inspiring leader of its constantly increasing personnel. The development of the Bureau to its present status is largely his monument." In addition to administrative duties Dr. Howard has been actively engaged, practically throughout his entire career, in the preparation and publication of papers on entomological subjects, and until 1907 he continued to work and publish on the classification of chalcid flies. Dr. Howard sailed from New York July 11 on the S. S. Virginia for San Francisco by way of the Panama Canal. From San Francisco he will go to Honolulu, where he will visit for some time and take part in the Pan Pacific Congress. Following the stay in the Hawaiian Islands he will go to Paris, France, where he will make his home with his daughter Janet and work on a number of publications on entomology. En route to France he will stop at Japan, China, and Palestine. At the latter place he will leave a colony of one of the parasites of the Mediterranean fruit fly, which is being sent there from Hawaii as an aid in the control of this pest. On June 12, Dr. Howard received word that he had been awarded the 1931 Capper gold medal and $5,000 for distinguished service to American agri-

culture. The award was made because of his outstanding services in perfecting insect control measures, principally in the biological method of control, and also for his work on the carriage of disease by insects. To celebrate his 74th birthday, on June 11, a dinner was given in his honor at the Cosmos Club and attended by a great number of his Washington associates and friends. Dr. Charles G. Abbot, Secretary of the Smithsonian Institution was toastmaster, and laudatory speeches were made by Dr. A. F. Woods, Director of Scientific Work of the Department, and by five other of Doctor Howard's friends. During the last few weeks before his retirement many of his colleagues called on him to show their appreciation of his work and to wish him a happy and successful voyage. On June 26 the Washington personnel of the Bureau, through their spokesman, Miss Mabel Colcord, presented him with a camera and writing portfolio as a token of esteem and appreciation. The members of the Cosmos Club were given an opportunity to bid farewell to Dr. Howard at an informal reception held in his honor on the evening of June 29.

Horticultural Inspection Notes

Mr. S. S. Sheffield was reinstated in the Division of Foreign Plant Quarantines on July 6, 1931 and assigned to the port of Mobile, Alabama.

The Plant Quarantine and Control Administration, on May 8, 1931, issued circular PQCA-311, under which the importation under permit of frozen pack fruits is authorized.

During the first part of June, Mr. Geo. G. Becker of the Plant Quarantine and Control Administration, visited Porto Rico in the interests of the inspection work being carried on on that island.

A list of plants exempt from gipsy moth certification requirements under Quarantine No. 45 was issued on June 19, 1931, by the Plant Quarantine and Control Administration as circular PQCA-313.

Messrs. R. G. Oakley and N. O. Berry, formerly engaged in the Mediterranean fruit fly project in Florida, were transferred to Porto Rico on April 16 and May 1, respectively, to assist in the port inspection work on that island.

Mr. E. R. Sasscer attended a conference of Mexican border inspectors at Laredo, Texas on June 23 and 24. Before returning to Washington Mr. Sasscer visited the Mexican border ports east of Laredo and also several of the southern maritime ports.

Mr. R. L. Trigg, who has been in charge of the plant quarantine work in Gulfport, Mississippi for the past year, was transferred to Corpus Christi, Texas, on July 1. Ship arrivals at Gulfport in the future will be handled from the Mobile office.

Inspection of express, parcel post, and freight, at Springfield, Mass., primarily for the purpose of the enforcement of the European corn borer and gipsy moth quarantines, was started on May 26. Mr. Warren M. Davis has been assigned to this work.

The Nevada State Quarantine Proclamation on account of the Oriental fruit moth, which became effective on April 10, 1931, includes the States of Illinois, Kentucky, Massachusetts and Michigan, not heretofore restricted under the Nevada State quarantine.

Three circulars summarizing the plant quarantine laws of New Zealand, Peru and Central America have been issued recently by the Plant Quarantine and Control Administration. These circulars are numbered PQCA-306, PQCA-310, and PQCA-314, respectively.

In the future, dealers in nursery stock in the State of West Virginia will pay $5 license fee, instead of $20 as heretofore required under Section 15 of the Crop Pest Law of that State. Nursery dealers having more than one place of business will pay $5 for each place where they dispose of nursery stock.

A synopsis of the sterilization and disinfection treatments of plants and plant products authorized by the Plant Quarantine and Control Administration as conditions of certification under foreign and domestic plant quarantines has been issued by the Administration as circular PQCA-309.

The Virginia Japanese Beetle Quarantine has been revised by the officials of that State to coincide with the Federal Quarantine revision effective November 10, 1930, and the quarantine which regulated the shipment of Christmas greens into Virginia has been lifted, owing to the fact that this matter was taken care of by Federal quarantine.

Shipments of "onion, cabbage (and other cruciferous plants), tomato, or sweet potato plants, or seed sweet potatoes" into Akansas must be accompanied by permit-certificates of the Arkansas State Plant Board, according to a statement issued by the Chief Inspector, Paul H. Millar, under date of April 10, 1931.

The Oregon State Board of Horticulture has issued a quarantine order (No. 20, effective May 7, 1931) restricting the entry of host vegetables and host plants of the vegetable weevil (*Listroderes obliquus* Gyll.) from infested counties in California, and requiring that shipments from the noninfested areas shall have the waybills marked as to point of origin.

A law creating a new Department of Agriculture in the State of Oregon became effective July 1, with headquarters in the State Building, Salem, Oregon. Max Gehlhar has been appointed Director of Agriculture, and Chas. A Cole, Chief of the Bureau of Plant Industry. The Bureau of Plant Industry will have charge of the horticultural work.

The Federal inspection of nurseries in New England and New York which desire to ship five-leafed pines into States that are only lightly infected with white pine blister rust, was carried out during May and June by Messrs. R. A. Sheals and H. J. Conkle of the Plant Quarantine and Control Administration. Similar nursery inspections are being made in the Pacific Northwest by C. R. Stillinger.

In view of the finding of *Peronospora hyoscyami* in tobacco beds in five counties in Georgia, the North Carolina Commissiner of Agriculture has issued a quarantine

order, dated April 28, 1931, (according to the Agricultural Review of Raleigh, N.C.) declaring that "all tobacco plants originating in the State of Georgia and moved into or within the State of North Carolina shall be subject to seizure....".

The Virginia Department of Agriculture reports that during the winter months a considerable acreage of red cedars was cut over by the State forces under the Cedar Rust Law in five of the commercial apple-growing counties. The report states that very little opposition was encountered and at the present time there are only two cases that have been appealed and are likely to be taken up through the courts. Very few cedar rust balls were found on red cedar trees this year.

The Wisconsin Department of Agriculture reports the following nursery inspection personnel for the year: Noel F. Thompson, Frank B. Sazama, Alvin L. Piller, Otto H. Richter, and Hubert Halliday, working under the direction of the State Entomologist. The season's activities were reported on June 16 as already under way, and the regular raspberry inspections were to start the following week.

The narcissus inspection records for 1930 have been published by the Plant Quarantine and Control Administration as PQCA-312. These tables will be reprinted as a permanent record in the Service and Regulatory Announcements of the Administration for April to June, 1931 (SRA-107) and are issued in the present form, several months in advance of publication of those Announcements, in order that they may be available for growers and others interested.

The inspectors of the Rhode Island Department of Agriculture have been making a special effort this spring to clean up all areas around nurseries to eliminate infestations of gipsy moth, and to eradicate Ribes which are secondary hosts of the white pine blister rust. The inspections for this season began shortly after July 1. The number of nurseries has increased from 52 to 65 since the 1929 inspections and their area has increased about ten per cent.

Mr. Avery S. Hoyt has been appointed Assistant Chief of the Plant Quarantine and Control Administration, according to an announcement issued June 29, 1931. Mr. Hoyt graduated from Pomona College, where he specialized in Entomology. He has had long experience in plant quarantine work, having entered the port inspection service of the State of California in January, 1912. In December, 1929, he was made Assistant Director of the California Department of Agriculture, and in February, 1931, was appointed Director of that Department.

Mr. E. L. Chambers, State Entomologist of Wisconsin, is trying out several unique methods of distributing information to nurserymen and others in Wisconsin who are interested in plant pest and disease control. One item is a blotter, which gives information concerning control of white pine blister rust; another is a tag entitled "To Grow Sound Fruit", on the back of which is a spray calendar, while a third consists of a tag entitled "Keeping Evergreens Healthy", which gives control measures recommended for use against red spider attack.

The Territory of Hawaii has issued Rule XXIX forbidding the importation, except as provided in the regulations, of all citrus and persimmon fruits from the State of California, on account of "certain injurious insects, including the citrophilus

mealybug (*Pseudococcus gahani* Green), the maritime mealybug (*Pseudococcus maritimus* Ehrh.) and the bean thrips (*Hercothrips fasciatus* Perg.)." This rule was adopted on August 30, 1930. Rule XXX, adopted on November 26, 1930, forbids the importation of "all bacteria fungoid and virus cultures and specimens incident to agiculture" from all countries and localities.

During the week of June 3, a series of meetings were held in Washington, attended by port inspectors in charge of the stations at Boston, New York, Philadelphia, Baltimore, Norfolk, Charleston, Mobile, New Orleans, Detroit, Seattle, and Honolulu. The meetings were also attended by Messrs. A. C .Fleury, Supervising Quarantine Officer of the California Department of Agriculture; J. H. Montgomery, Quarantine Inspector of the Florida State Plant Board; L. A. Whitney of the Hawaiian Board of Commissioners of Agriculture and Forestry, and by various employees of the Washington office. During the meeting the various problems which arise at the different ports were thoroughly discussed.

A revision of the Federal gipsy moth and brown-tail moth quarantine regulations was issued effective June 1, 1931. The revised regulations modify the restrictions on the shipment of Christmas trees and greenery, forest plant products, stone and quarry products, and nursery stock from the areas infested with the moths concerned in the New England States. The primary purposes of the revision are to clarify the definition of restricted articles and "to authorize the recognition of valid State nursery inspection certificates as evidence of freedom from the brown-tail moth with respect to certain shipments of deciduous trees and shrubs moving to points within the gipsy moth infested areas."

The annual inspection of nurseries in Virginia was started early in July. Excellent cooperation has been received on the part of nurserymen and others who have box shrubs infested with the Leaf Miner. The Virginia inspectors discovered, however, one shipment of plants from one of the northern tier counties to Richmond. So far as the State officials have been able to determine, the Boxwood Leaf Miner in that State occurs only in the northern counties bordering the Potomac, and they are very desirous of keeping it from being spread about the State, and especially to old boxwood gardens of the colonial plantations.

Due to apparent scarcity of citrus fruits in Texas after April 6, 1931, the Commissioner of Agriculture issued an amendment to Quarantine Proclamations Nos. 29, 31, 32, 33, 34, and 37 "so as to permit the entrance of Florida citrus fruit into that portion of Texas herein defined as North Texas, during the period beginning April 6 and ending September 1" when such fruit is packed and marked according to the requirements. The North Texas area is described as "north of and including the counties through which the main line of the Southern Pacific traverses the State of Texas from the Louisiana line in Orange county to the western boundary of Valverde county." The statement of the quarantine takes into consideration the pest risk, but points out that "the State is in position to maintain the control necessary for the enforcement of this proclamation for the period specified" and that "when Texas production again is available there will be no further need to assume continuance of the risk involved."

The South Dakota nursery inspection laws were amended in the 1931 session, the principal changes consisting of (a) defining "nursery stock" to include "all florist stock which is not grown under glass; trees, shrubs, vines, cuttings, grafts, scions, buds, fruit-pits and other seeds of fruit and ornamental trees and shrubs and other plants and plant products having the capability of propagation or of growing when planted, except field, vegetable and flower seeds, bedding plants and other herbaceous plants, bulbs and roots other than peony, strawberry and asparagus;" and (b) striking out the provision that an out-of-State dealer may obtain a certificate by filing a copy of his inspection certificate and paying a fee of one dollar. A fee of ten dollars is now charged, and "Such certificate shall be granted only to individuals who purchase their stock from a certified nursery in this State or from a foreign nursery whose stock, which is to be sold in this State, has been inspected in this State and found apparently free from injurious insects, archnids, worms and dangerous plant diseases."

On June 26, the Secretary of Agriculture announced a revision of the Federal black stem rust quarantine (No. 38), effective August 1, 1931. The present quarantine, which has been in effect since May 1, 1919, prohibits the shipment of 31 species of Berberis and, as amended, 3 species of Mahonia, from 35 eastern, southern, and western States into 13 north central States which have been engaged in barberry eradication for the protection of grain against black stem rust infection. The 13 protected States are Colorado, Illinois, Indiana, Iowa, Minnesota, Michigan, Montana, Nebraska, North Dakota, Ohio, South Dakota, Wisconsin, and Wyoming. The revised quarantine will include the 13 protected States with the 35 States and the District of Columbia now covered, and will restrict the interstate shipment of Berberis and Mahonia plants among the protected States. Under an additional change in the regulations, nurseries which grow only immune species of Berberis and Mahonia will be supplied with Federal permits for the shipment of immune species into and between the 13 protected States. Lists of immune and susceptible species and varieties can be obtained by addressing the Plant Quarantine and Control Administration.

Alfalfa meal, when certified and shipped according to requirements, may now be shipped at any time of the year from the alfalfa weevil infested areas into the States of Michigan, Wisconsin, Illinois, Missouri, Nebraska and Kansas, according to recent regulations issued by these States. The former embargoes, prohibiting the entry of alfalfa meal during a part of the year (the entire year in the case of Missouri) have been lifted. The infested areas as designated by the new regulations includes the following counties not appearing in the former orders: The Michigan quarantine includes Alpine County, Calif., Garfield and Mesa Counties, Colo., Douglas, Elko, Humboldt, Lincoln and Nye Counties, Nev., Jackson County, Ore., and Hot Springs County, Wyo. The Wisconsin quarantine now includes Niobrara County, Wyo. The Nebaska quarantine is extended to Alpine County, Calif., Elko, Humboldt, and Lincoln Counties, Nev., Jackson County, Ore., and Hot Springs County, Wyo. The new counties covered by the Kansas quarantine are Alpine County, Calif., Esmeralda and Nye Counties, Nev., Jackson County, Ore., and Hot Springs County, Wyo. Under an amendment to the alfalfa weevil quar-

antine of the State of California, a portion of Jackson County, Ore., is declared exempt from the provisions of the quarantine when the restricted commodities are accompanied by a certificate giving certain information as to the origin and storage of the materials. The amendment was issued May 28, 1931 and remains in effect until March 1, 1932.

Apiculture Notes

C. L. Farrar, Assistant Professor of Entomology and Beekeeping at the Massachusetts State College, has been appointed Field Assistant at the Somerset Laboratory to devise a method for obtaining accurate information on the rate of flight of bees.

J. E. Eckert, Bureau of Entomology of the Intermountain State Bee Culture Laboratory, returned to his official duties on June 3, after a year's leave of absence at Ohio State University, Columbus, Ohio, where he received the degree of Doctor of Philosophy.

Alice Mayo has been appointed Field Assistant at the Bureau of Entomology, Somerset, Md., field laboratory to assist in research work on bee diseases, and W. Haydak has been reappointed Field Assistant to continue work on the nutritional requirements of the honeybee at the Somerset Laboratory.

A colony of bees was recently installed in a glass observation hive in the new reptile house at the National Zoological Park, Washington, D. C. Some difficulty was experienced in installing the bees, inasmuch as it was necessary for them to traverse a long tunnel before they would be free to fly. After certain changes had been made to improve the ventilation of the colony, the bees accepted their new quarters and are now reacting quite normally.

Reports have been received from Nevada and California, as well as from certain places in the Eastern States, of the abnormal death of adult bees. The trouble is invariably reported as paralysis. No one as yet has discovered the cause of this trouble, which is quite widespread, and it is not possible at present to make a definite diagnosis. The Bureau of Entomology Bee-Culture Laboratory has undertaken certain inoculation experiments with bees suffering from this adult trouble in the hope of discovering its cause.

Charalambos Simopoulos, Minister of Greece, accompanied by Angelo Anninos, Counselor of the Legation, visited the Bureau of Entomology Bee-Culture Laboratory on May 25. Mr. Simopoulos expressed great interest in the work of the Laboratory. He was anxious to obtain information relative to the beekeeping industry in the United States to transmit to the beekeepers in his own country, where an attempt is being made to place beekeeping on a modern basis. Mr. Simopoulos later sent two cans of Grecian honey of excellent quality to the laboratory to be included in the collection of foreign honeys. Considerable quantities of this honey are imported into the United States, going almost exclusively to the fancy retail grocery trade.

Notes on Medical Entomology

E. W. Laake, Bureau of Entomology, returned to his regular duties at Dallas, Tex., on June 20, after doing graduate work for several months at Iowa State College, Ames, Iowa.

The following temporary Field Assistants, Bureau of Entomology, reported for duty during the month of June: M. F. Canova, at Portland, Oregon, to assist in mosquito investigation; Adrian C. Fox, at Fargo, N. Dak., to assist in cattle grub investigations; Roy Melvin, at Galesburg, Ill., to assist in cattle grub investigations; and John B. Hull, at Charleston, S. C., to assist in sand fly investigations being conducted at that point.

Dr. W. E. Dove, Bureau of Entomology, spent the period, June 8 to 12 in Philadelphia, Pa., where he, in cooperation with Dr. Bedford Shelmore of Baylor University presented an exhibit before the American Medical Association on experimental transmission of endemic typhus through bites of tropical rat mites. For this exhibit Drs. Dove and Shelmire received the Silver Award of the Medical Association. Dr. Dove stopped in Washington before returning to his field station at Charleston, S. C., for the purpose of consulting with F. C. Bishopp and other Bureau officials. During the same period and before the same association, Dr. G. F. White and Paul A. Woke presented an exhibit on methods of rearing fly larvae for use in treatment of osteomyelitis.

Dr. William Robinson, until recently a member of the research staff of the Medical School of the University of Chicago, was appointed Senior Entomologist June 1, for duty in Washington, D. C. He has been placed in charge of the investigation of flies in relation to osteomyelitis. Dr. Robinson took his undergraduate work at the University of Toronto, his M.S. from the University of Kansas, and his Ph.D. from the University of Minnesota. He has given special attention to ecology, insect physiology, and entomological biochemistry. His work at the University of Chicago Medical School was upon certain phases of surgical shock of humans. This gave him excellent medical and surgical contacts which will be useful in the osteomyelitis project.